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to

"For their work continueth, And their work continueth
Broad and deep continueth Greater than their knowing"

Rudyard Kipling

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February 1949

The Journal of Bone and Joint Surgery

BUCKINGHAM PALACE

6th January 1948

My dear Sir Reginald Watson-Jones,

The King will be grateful if you will express to all the orthopaedic surgeons associated with you his sincere thanks for the copy of the first British volume of the Journal of Bone and Joint Surgery sent with your letter of January 1st, and for the good wishes that accompany it.

His Majesty is glad to have this record, in which he will find much to interest him.

Yours sincerely

Sir Reginald Watson-Jones,
FRCS.,LRCP.,
82 Portland Place,
W.1

VOL 31-B, No 1 FEBRUARY 1949

The Journal of Bone and Joint Surgery

HIS MAJESTY THE KING

A hand-bound copy of the first British volume of the Journal of Bone and Joint Surgery was presented to His Majesty the King by members of the British Orthopaedic Association, Canadian Orthopaedic Association, Australian Orthopaedic Association, and all the orthopaedic surgeons of the Commonwealth of British nations, together with an expression of their loyal appreciation of the King's interest, and his approval of their close collaboration with surgeons of the United States of America We are privileged to publish His Majesty's gracious reply

All surgeons of the English-speaking peoples join in expressing their sympathy with the King in his serious illness, and in acknowledging the indomitable spirit with which he faced disability and associated himself, in his Christmas message, with those of his subjects who are also disabled It is with great relief that we learn of the progress which has been made, and it is our sincere trust that His Majesty's recovery may be rapid and complete

EDITOR

BRACHIAL PLEXUS INJURIES

In 1864 Weir Mitchell published his account of a systematic study of the nerve injuries of warfare There were "about 120 cases, all of which have been carefully reported in our notebooks during the past year No labor has been spared in making these clinical histories as perfect and full as possible Those only who have devoted themselves to similar studies will be able to appreciate the amount of time and care which has been thus expended We indulge the hope that we shall leave on record a very faithful clinical study of nerve injuries, and that we shall have done something at least towards lessening the inevitable calamities of warfare" The time has again come when British workers in the same field are making similar contributions, with the difference that records are now numbered by thousands, and that workers in different centres have achieved remarkable uniformity of documentation

In this number of the Journal, D M Brooks gives the most complete report that has yet appeared of the end-results of open wounds of the brachial plexus On account of the complexity of the nerve trunks involved, a special method of grading recovery had to be devised, it has been successful in that it gives the careful reader a clear picture of what happens The most striking finding is the rarity of anatomical interruption It may be presumed that, owing to proximity of the great vessels of the limb, only men with comparatively benign injuries survived Recovery after a lesion in continuity of C 5 and 6, or of the posterior cord, was usually most satisfactory, but even where exploration showed an apparently favourable lesion of C 8 and T 1, or of the medial cord, recovery in the small muscles of the hand was usually so poor as to be useless, and no better in the three cases where surgical repair was undertaken The survey has thus led to an important practical conclusion that, with one exception, nothing was gained from exploration of a brachial plexus injured by an open wound The exception was a lesion involving C 5 and 6—where repair of a divided upper trunk may be worth while

Many cases of traction injury of the plexus were seen during the war, and in these days of high-speed road transport such injuries have a permanent interest Barnes describes his findings in sixty-three cases, and Kerr has added an interesting note on two cases in which the cervical plexus was also involved Hitherto, these injuries have been regarded with

profound pessimism, and treatment has been perfunctory, with the result that joint stiffness has been allowed to occur with depressing frequency Yet Barnes has shown that when conservative treatment was carried out thoroughly, and over a long period, there was surprisingly good return of function after many lesions of the upper three roots As after open wounds, recovery in the muscles of the hand after damage to C 8 and T 1 was poor Lesions involving the whole plexus never recover completely, and the presence of a Horner's syndrome is a bad sign In the early days of the war there was much talk of benefiting these cases by early exploration It was supposed that recovery might be hindered by extraneural scarring, and because late operation had been a failure it was thought that early exploration might, in some vague way, succeed But Barnes points out that extraneural scarring is incidental and that, as in traction lesions elsewhere, the significant damage is intraneural fibrosis There could hardly be a more striking demonstration of the slow and delayed influence of this scarring than Penfield's case in which after thirty-seven years it began to affect the spinal cord itself

Barnes is strongly and justifiably in favour of conservatism There is, nevertheless, an occasion when exploration may be useful If there is complete brachial plexus paralysis, an exploratory operation will show whether the plexus is still in continuity or is completely disrupted—if the latter then no time need be wasted on conservative treatment Bateman has contributed a valuable note on an approach to the plexus that is facilitated greatly by placing the patient in the sitting rather than in the supine position

No account of brachial plexus paralysis is complete without reference to the reconstructive measures that are often required in the treatment of residual paralysis, and endry has contributed an account which is based on very wide experience He is opposed amputation even of a completely paralysed part Perhaps, before long, there may be portunity to compare the results of his staunchly conservative surgery with those of mputation, and the fitting of a modern artificial limb He begins, appropriately enough, with the paralysed hand and describes a number of useful operations for activation of the fingers He is less sanguine about tendon transplantation for paralysis of the thumb and places more reliance on arthrodesis, sometimes combined with a flying buttress between the first and second metacarpals to hold the thumb in palmar abduction But Hendry's conservatism is full of surprises and he has no hesitation in challenging the value of conservative procedures which are commonly accepted While not condemning arthrodesis of the wrist joint he regards this operation as of limited value and often inferior to his ingenious flexor-extensor tenodesis Again, in choosing the position of the forearm he prefers full supination for the patient with a flail hand though he agrees that the mid-position is better cosmetically Having dealt with the hand he tackles the elbow by means of a posterior bone block, an operation that he has performed twenty-one times, in nine cases the limb was completely flail He makes out a good case for this novel procedure

No two paralysed arms are identical It is difficult to formulate rules that can be applied to every case, and Hendry has not succeeded in doing so What he has done is to impress on his readers the necessity for careful analysis not merely of the extent of paralysis but of every concomitant joint contracture, only then can the operative procedures, arthrodesis, tenodesis, tendon transplantation, and bone block of joints be deployed in the right combination and the right order

H J SEDDON

ROWLEY BRISTOW MEMORIAL FUND

The Rowley Bristow Memorial Fund will be closed very shortly It is proposed to establish a lectureship, or a student scholarship, by which to perpetuate the memory of a great British orthopaedic surgeon who was respected no less in the United States of America than in Great Britain The attention of readers is called to a letter, in the correspondence columns of this number of the *Journal*, from Professor George Perkins

EDITOR

THE SCIENTIFIC APPROACH TO ORTHOPAEDIC SURGERY

S ALAN S MALKIN

President of British Orthopaedic Association *

In choosing the subject of their presidential addresses some of my predecessors selected clinical matters in which they were specially interested, while others made observations of a more general character Much of what I shall say to-day is the outcome of informal discussion with colleagues, young and old, and my purpose is to refer to certain aspects of our work which warrant more attention than they have received Just as in the life of an individual it is necessary from time to time to reflect, and to consider whether objectives are being achieved, so in the life of a Society it is advisable occasionally, but not too often, to review the past, assess the present, and look into the future This is particularly important to-day, not simply because this year our Association completes thirty years of life, but because we are living in difficult and changing times when it is more than ever necessary to see clearly where we are going

I propose first to recall to your minds certain facts with which older members of the Association are familiar but which are less well known to younger members, and particularly to contrast the status of orthopaedic surgery at the time of the first World War with its status to-day When war was declared in 1914 there were few orthopaedic surgeons in England One—Sir Robert Jones—was outstanding both nationally and internationally At that time there were few orthopaedic hospitals, but by the efforts of this great leader a number of special military surgical hospitals were established Through his influence, American orthopaedic surgeons came over to England to assist in staffing these hospitals it would have been quite impossible for Great Britain herself to supply all the surgeons necessary It is interesting to remember that these hospitals were called " Special Military Surgical Hospitals " and not " Orthopaedic Hospitals " The word orthopaedic was not well received by some surgeons and it was thought better to avoid the use of it—an interesting commentary on the position at that time Even by the standards of to-day you would have regarded these special hospitals as complete and fully equipped There were, of course, differences For example, no facilities were provided, as they were in the recent war, for strenuous exercises and games in the final stages of rehabilitation, nor were there special occupational therapy departments Nevertheless, workshops were recognised as essential parts of the hospitals, and Sir Robert Jones was particularly keen that men should restore themselves to health and strength by their own efforts, and not rely on passive physiotherapy to do the job for them

These hospitals prevented much deformity and disability, and later it was urged that the facilities which had been provided for the casualties of war should be made available to the cripples and potential cripples of peace In 1919, Robert Jones and Gathorne Girdlestone published an article in the British Medical Journal which outlined a national plan for the prevention and treatment of crippling conditions, and for the training of cripples who could not easily take their place in the ordinary life of the community This was one of the first experiments in Social Medicine, practised long before the birth of that subject as we know it to-day The establishment of country orthopaedic hospitals was advocated, which with out-patient clinics and workshops would form complete units The disinterested enthusiasm of many to whom this scheme appealed made it possible for such orthopaedic units to be established in Great Britain, ready to play their part in dealing with the casualties of the second World War This time there was no doubt of the need for orthopaedic surgery and

* *Presidential Address delivered at the Annual Meeting of the British Orthopaedic Association in Belfast, October* 1948

orthopaedic hospitals New hospitals had to be established for the reception of casualties, but those already in existence formed the nucleus of the national orthopaedic service This in itself is an indication of the progress which has been made There are many others, such as the fact that Chairs of Orthopaedic Surgery have been established in Oxford, Liverpool, and Manchester, that an orthopaedic surgeon has recently been appointed as professor of surgery at a London teaching hospital, that two leading members of our association are Members of the Council of the Royal College of Surgeons of England, and that, twice since its formation, the International Society of Orthopaedic Surgery has had for its president one of our members It is fair to say that there are now few hospitals of size and standing in Great Britain without orthopaedic departments staffed by trained orthopaedic surgeons Orthopaedics now, without question, embraces traumatic surgery, it co-operates with those who practise neurosurgery and plastic surgery, and it seeks within itself to develop such special work as the surgery of the hand It has achieved this position not by narrowing but by broadening its outlook, and it insists that young orthopaedic surgeons should first gain a sound knowledge of, and a higher qualification in, general surgery

From every point of view the Association can look back on the period since the first World War as one of great development and progress But the real test of health and vigour is whether orthopaedic surgery attracts young men of ability and character who see in it the opportunity to lead useful and satisfying lives Are they so attracted? The succession of young men who have joined the ranks of our Association gives, not a weak, but a strongly affirmative answer to that question It might be considered, therefore, that all is well, and that for progress to be maintained it is necessary only to continue on the lines already laid down There are good reasons for believing that there need be no anxiety as to the security of the position of British orthopaedic surgery, but fortunately, as I believe, there are many weighty reasons for thinking just the reverse If we are to continue to make that contribution to leadership in orthopaedic surgery, as practised throughout the world, which we could and should make, there is need for very clear thinking and for strenuous effort I said that this was fortunate, for if a real effort on our part were not required we might fear that, added to our other troubles, there had fallen on Europe the worst of all evils—intellectual stagnation

In our Constitution the object of the Association is stated to be "the advancement of the science and art of orthopaedic surgery" You will notice that it is not "the art and science," but "the science and art" It may be that the words were placed in that order for the sake of euphony, or because of custom, but it may also be that the order was chosen deliberately Whatever the reason, I think it cannot be disputed that we have reversed the order and put art before science Many of us have concentrated so much on technique and technical matters, which may, after all, be no more than temporary and short-lived, that we have neglected almost completely the scientific aspect of our work which could make a permanent contribution to knowledge This does not mean that the standard of orthopaedic surgery in this country is low I believe that any patient requiring orthopaedic treatment, wherever he lives in Great Britain, has within easy access the facilities which are necessary to give him sound and efficient treatment But there has been greater interest in technical advance and new methods than in scientific progress, and there is no doubt that much of our work is empirical

We know that many of the methods we employ depend on impressions of our results, sometimes indeed on our temperaments, and on changing fashions, rather than on clear and logical thought Statistical analysis of our cases, and of our methods, is not always adequate, and sometimes, unwittingly on our part, we draw inferences which are quite incorrect and misleading I fear that many of them would not bear the scrutiny of a trained statistician We have all had the experience of visiting a hospital and being shown satisfactory results from one method of treatment, while at another hospital methods which were apparently quite different were claimed to be equally good There are many instances for example, the

treatment of fractures of the spine with or without plaster fixation, the treatment of sciatica by rest or by operation, the functional as opposed to the anatomical treatment of fractures and there are other, and perhaps better, examples There must be some explanation for this diversity It may be that we are unable to assess clearly what we have done It may be that on occasion we have over-persuaded patients who will not let us down It may be that we aim at producing the satisfied patient—an aim not to be belittled, but not the scientific test of success, or it may be that in diverse treatments there are common factors which themselves, though unrecognised, are the real causes of success Such possibilities have this in common—they show a lack of the scientific outlook I do not suggest that this is a British failing alone, although it may well be one to which we are prone because of our national instinct, and our tendency not to worry too much about theories but rather to aim at results As "a nation of shopkeepers" it is perhaps not unnatural that we should be concerned with the delivery of goods This is of course vitally important, and it does keep our feet firmly on the ground, but nevertheless it can be a source of weakness

It may be contested that orthopaedic surgeons have taken full advantage of scientific developments and that there is no comparison between the results of treatment during the first and second World Wars It may be said that many men who were injured in the second World War would never have returned to duty if they had been injured similarly in the first war This is true, but it does not necessarily mean that orthopaedic surgery itself has become more scientific, it may be no more than that orthopaedic surgeons have utilised the results of the scientific work of others—work which produced penicillin, sulphonamides, and inert metals, which is a very different matter I would not like it to be thought, and indeed it would be unjust to say, that really good scientific research has not been carried out, but what I do say is that many members of this Association have been concerned with practising orthopaedics as an art and not as a science Few of us have that detached point of view which made Lambrinudi's observations of such value

If we are to achieve the objects of this Association we must become more scientifically minded We must give more attention to research in all its forms clinical observation, experiment in man, and experiment in animals Some years ago Wilfred Trotter pointed out that clinical observation, except in the hands of an occasional genius, had not been a very effective instrument by which to penetrate the fundamental secrets of health and disease, but that nevertheless it could be an important instrument for assessing the results of treatment if it was recognised, not as a spare time hobby to be indulged in when a paper was to be written, but as work which must be done constantly It may be felt that, for such clinical observation, much time must be given, and that in our over-worked state this is not possible There is much truth in this But the difficulty could be overcome if sufficient men of the right calibre—those who had reached the senior registrar or assistant surgeon status, having first gained some knowledge of statistics—were available to collect cases and assess treatment as part of their normal work I do not think that many men, except occasionally and for a limited period, should devote their whole time to this type of research, but it should be one of their duties, at least in the early stage of their careers The work of one man, dealing with a particular problem, should not necessarily be confined to one unit or centre, if it were not so confined the same judgment could be applied to comparable groups of cases treated by different methods It would be possible in these circumstances for a man—if his mind were acute enough—by assessing the results of different types of treatment to find out what really was essential in each, thus at the same time advancing knowledge and simplifying treatment He might also, by carefully assessing symptoms, deduce their real causes Clinical observation, properly organised and conducted, could yield a rich harvest

Experiment in man has some value in orthopaedic surgery but the application is limited It may be used from time to time to prove that deductions made from clinical observations are correct As a rule, however, such experiments as are possible will deal more with methods

of treatment and technique than with assessment of the causes of disease As an instance I would quote from the diary of Dr John Knyveton (1763–1809) "June 3, 1777 M Sigault, a surgeon of Paris, has made a great noise and stir by dividing the pubic symphysis in a case of child-birth, in order to free the child's head by dividing the bony ring of the pelvis The French government have awarded him a pension, and a medal has been struck in his honour but I do not like the sound of the business at all, and have but lately returned from Mr John Hunter, with whom I discussed the matter Nevertheless, in order that the exact degree of utility of this new operation may be accurately assessed, Mr Hunter will perform a series of operations on the symphysis in company with his brother William and Mr Osborne is to collect all information, examining the cases published and the results of the operations of the brothers Hunter, so as to prove by facts and experiments the use or otherwise of this new treatment " This is surely the plan—experts to perform the operation, and independent observers to assess the results

Apart from clinical observation, the method to which we must look for most advance in orthopaedic surgery is animal experimentation and laboratory research But here is a great difficulty few of us are trained research workers, and moreover it is hard to combine research with routine clinical duties It is probably true that research is best done by the young Indeed it is said by some of considerable experience that the best and most original research work is done before the age of thirty This does not mean that no research is done after that age but very often, though carried out later, it was conceived in youth Lister and Hunter began their experiments when they were still young Isaac Newton made discoveries at the age of twenty-four, and it is interesting to remember that his great work was begun in the disturbed years of the Plague, and the Fire of London, in 1665 and 1666, when there was probably far less security of life than there is to-day Referring to himself when he was at this age, Isaac Newton said "I was in the prime of my age for inventions, and minded mathematics and philosophy more than at any time since " It may be, as Francis Bacon observed "the invention of young men is more lively than that of the old, and imagination streams in their minds, as it were, more divinely " The concensus of opinion seems to be that youth is the best time for research The point for us is that the man who specialises in orthopaedic surgery, and who reaches the status of an assistant orthopaedic surgeon by about the age of thirty, will have passed the time when he could have done his best work Moreover, research demands much knowledge of the basic sciences, it must be carried out in institutions, and it must be correlated with work in other fields How can the dilemma be overcome? First by close co-operation between orthopaedic surgeons and physiologists Just as in some clinics the anatomist is a member of the orthopaedic team, so the physiologist should be invited to join us and find answers to some problems which can be solved only in the laboratory The physiologist could do fundamental research, he would be the link with other sciences, and our part would be to put problems before him, to discuss possible solutions, and to assist in technical details as required May I remind you that twenty-seven years elapsed before recognition of the enormous clinical value of sulphanilamide, discovered in Vienna in 1908 by a scientist, Gelmo, and that it was very many years after Sir Alexander Fleming discovered penicillin in his London laboratory that clinical applications were first made The links between medicine and science must be forged much more strongly

My second proposal is that every man while training in orthopaedic surgery should, during one year, spend time in the research laboratory This need not necessarily be full-time work, nor do I think that every man is equally fitted for research But I do believe that, whether fitted or not, such experience would stimulate his scientific outlook As Goethe said "He who with inadequate talent devotes himself to music will never indeed become a Master, but he will learn to know and value a masterly production "

I must turn for a moment to the National Health Services Act, which is having such far-reaching effects on our profession Section 16 states "1) Without prejudice to the general

powers and duties conferred or imposed on the Minister under the Ministry of Health Act, 1919, and the duties imposed on the Committee of the Privy Council for Medical Research under the said Act, the Minister may conduct or assist by grants or otherwise any person to conduct research into any matters relating to the causation, prevention, diagnosis or treatment of illness or mental defectiveness 2) The Board of Governors of a teaching hospital and a Regional Hospital Board and a Hospital Management Committee, shall have power to conduct research into any of the matters aforesaid " The Government, therefore, directly through its hospital boards and management committees, has assumed the duty of providing research facilities, and it is for us to see that these facilities are developed fully The executive of this Association has felt that it could assist in co-ordinating research by forming a special research committee To this committee anyone can appeal for assistance, particularly when work is to be done at more than one centre The committee will serve in promoting liaison and it may also initiate special studies

Important research is being carried out in many parts of the world Investigations have been undertaken in America on the mineral and protein content of bone in relation to function and form Work in the University of Chicago on the spontaneous recovery of muscles after incomplete denervation may have important applications in the treatment of infantile paralysis In Stockholm the properties of articular cartilage in the normal subject, and in various pathological states, has been studied There have been important studies in this country, and at this meeting you have heard of the research of young members of our Association into the regeneration of human muscle after ischaemic necrosis, and the causes of premature epiphyseal fusion in osteoporosis But how much more there is to be done Consider the problem of scoliosis Is so-called idiopathic scoliosis always, or sometimes, due to unrecognised poliomyelitis? Can its progress be prevented in the early stages? What is the best method of treatment? And again, why does the upper femoral epiphysis sometimes slip in adolescence? We have concentrated on treatment, but the real problem is that of prevention, and there is need for both physiological and biochemical studies Think of the problems of sciatica What is the physiological, anatomical, and pathological background of degenerations and displacements of disc lesions? Can they be prevented? Many other examples will come to the mind of every member of the Association

In conclusion, I would remind you that in concentrating on the scientific aspect of our work we should do no more than return to the ideals of the founder of British scientific surgery—John Hunter In delivering a Hunterian oration, Sir James Paget said " Hunter's greatest work was in physiology He brought the scientific method into the study of practice and he welded scientific knowledge with the lessons of experience Either science or art can do many things, even a one-handed man is far from helpless, but two hands are better, they should work together in harmony with mutual help, for the best work can be done only when the power and skill of science and art are combined, as with one thought and one design It was thus that Hunter wrought in surgery "

Let us make this our aim Let us combine the science and art of orthopaedic surgery as with one thought and one design

TRACTION INJURIES OF THE BRACHIAL PLEXUS IN ADULTS

ROLAND BARNES, GLASGOW, SCOTLAND

From the Department of Orthopaedic Surgery, University of Glasgow

During the recent war many traction injuries of the brachial plexus were treated in the Peripheral Nerve Injury Centres which were established under the aegis of the Medical Research Council of Great Britain This paper is a review of sixty-three closed injuries of the plexus which were treated in three of these centres It does not include any post-anaesthetic lesions The mechanism of injury, and the factors influencing the prognosis, are discussed and evidence is cited to support the principle of conservative treatment of the primary nerve lesion

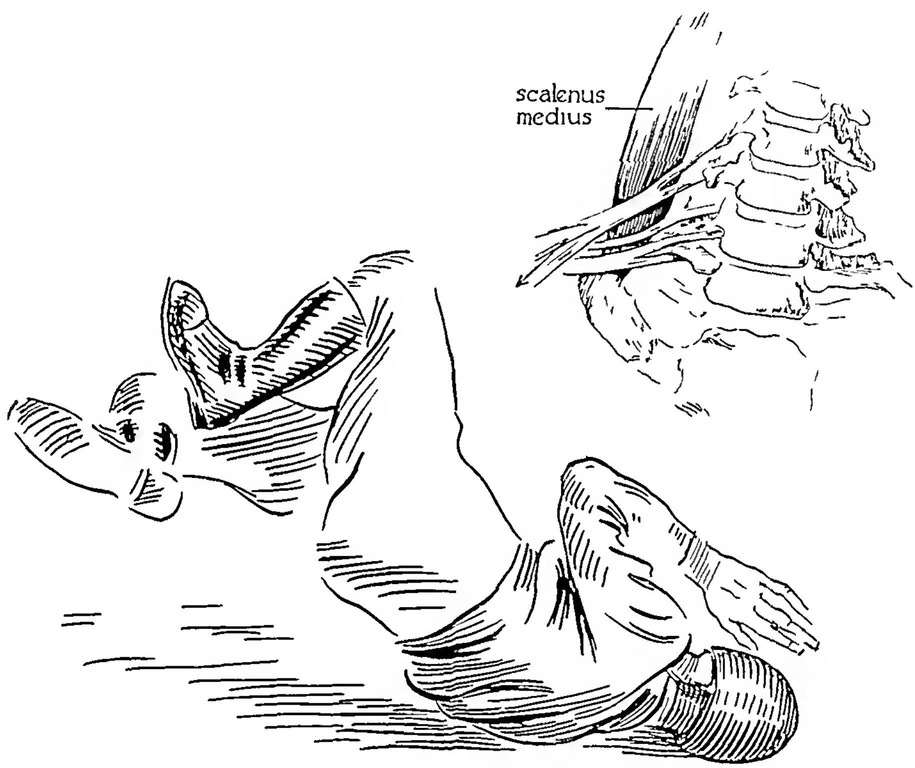

FIG 1

Mechanism of traction injury of the upper roots of the plexus With the upper limb by the side the head and shoulder are forcibly separated Most stress then falls on the upper roots

MECHANISM OF INJURY

Motor-cycle accidents are responsible for most traction injuries of the plexus The patient is usually unconscious for some hours, and very often the mechanism of injury is conjectural It is agreed, however, that in traction injuries the essential factor is forcible separation of the head and shoulder, the position of the upper limb at the moment of impact determining the particular roots of the plexus which will receive the brunt of injury

The brachial plexus is protected by the scalene muscles and by a strong layer of deep cervical fascia Violence must be severe enough to tear the fascia, and rupture the scalene muscles, or to avulse the tubercles of the transverse processes from which the muscles arise, before stretching of the nerve roots can occur

When the shoulder is forcibly depressed with the arm by the side the greatest stress falls on the upper roots, and it is impossible to put the lower roots under tension (Fig 1) The violence may even cause downward dislocation of the first rib, but the lower roots still escape injury if the limb is by the side Some additional factor must therefore operate when the lower roots are damaged irreparably It can be shown by experiment on the cadaver

that tension is exerted on all roots of the plexus when the abducted limb is forced behind the trunk and the head is thrust towards the opposite side (Fig 2) The tension on each root varies with the position of the limb elevation increases tension on the lower roots, adduction increases tension on the upper roots These observations are in accord with clinical findings, for lesions of the whole plexus may be divided into three types 1) lesions with permanent paralysis of all muscles of the limb, 2) lesions in which there is early return of voluntary power in muscles innervated by the lower roots, and no recovery in muscles innervated by the upper roots, 3) lesions in which there is late return of voluntary power in muscles innervated by the upper roots, and no recovery in muscles innervated by the lower roots

The lower, or Dejerine-Klumpke, type of paralysis is uncommon in adults There was

Fig 2

Mechanism of traction injury of the whole plexus The abducted upper limb is forced behind the trunk and the head is thrust towards the opposite side All roots of the plexus are then under tension

no pure lesion of C 8 and T 1 roots in this series, but two patients had a lesion of C 7, C 8, and T 1 roots which were not caused by motor-cycle accidents One patient was blown up by a land mine, and the other was involved in an aeroplane crash, both were unconscious for several hours and it was not possible to elicit details of the mechanism of injury The probable explanation of the rarity of the Dejerine-Klumpke type of palsy is that in adults violent traction is seldom applied to the fully elevated upper limb, and that the shoulder girdle has not the same mobility in adults as in the new born

NATURE OF INJURY

Substantial stretching of nerve roots is possible before actual rupture occurs Many surgeons believe that rupture of the roots of the brachial plexus is frequent, and this belief has dominated the treatment of traction injuries of the plexus It is one of the

favourite arguments advanced in support of early operation Nevertheless, Stevens (1934) stated that rupture of nerve roots with complete separation of the torn ends was a rare lesion, and this view is supported fully in this series by observations made at the time of operation Ten severe injuries of the brachial plexus were explored and in only one patient was there complete rupture of the nerve roots

Moderate stretching of a nerve root causes temporary inhibition of conductivity which affects the motor rather than the sensory fibres There is no degeneration of the nerve distal to the lesion and complete recovery occurs within two months of injury

Traction injuries of greater severity cause a degenerative lesion of the axons but no disturbance of the internal architecture of the nerve Spontaneous recovery of function may be expected, though it is slow because many regenerating axons have to travel long distances before connection with their end-organs is established With proper treatment, complete recovery may be expected, though not in the intrinsic muscles of the hand Failure of recovery in these muscles may be explained by irreversible changes occurring in the motor end-plates before the axons re-establish connection with them

Traction injury of still greater severity causes disruption of the axons and considerable damage to the intraneural blood vessels and connective tissue Intraneural scarring is then inevitable, recovery is patchy and incomplete, or it may even be prevented altogether

Very great violence may rupture one or more roots of the plexus The rupture is never clean cut, and it is always associated with severe scarring of both stumps for some distance on each side of the rupture For this reason it is impossible to perform satisfactory end-to-end suture of the ruptured nerve after adequate resection of the stumps, and nerve grafting is the only feasible method of restoring continuity

Most brachial plexus injuries are mixed lesions, for there is wide variation in the traction violence applied to individual nerve roots All traction injuries are of considerable extent and, in the more severe lesions, several centimetres of the nerve may suffer gross intraneural damage It is important to appreciate that it is intraneural damage, and not extraneural scarring caused by associated soft tissue injury, which is the barrier to recovery

CLINICAL FEATURES

Traction injuries of the brachial plexus may be divided into four main groups 1) lesions of C 5 and 6, 2) lesions of C 5, 6, and 7, 3) lesions of the whole plexus, 4) lesions of C 7, C 8, and T 1 The distribution of anaesthesia and muscular paralysis in each of these groups is too well-known to require description The muscular branches are not always derived from the same roots of the plexus and for this reason there is some variation in the extent of paralysis in each group Sometimes the third and fourth cervical roots are involved in the traction injury, in which case the area of anaesthesia extends over the shoulder on to the side of the neck

Paralysis is always most extensive immediately after injury Study of these cases has produced no evidence to support the contention of Davis, Martin, and Perret (1947) that "subsequent extensive scar tissue formation tends to impair to various degrees many originally uninjured portions of the plexus, and gives rise to disseminated and incomplete motor and sensory disturbances" This view is still widely held and it is responsible for much futile and even mischievous surgery

It is impossible by clinical examination to determine the prospects of recovery in degenerative lesions of the nerve roots The clinical picture of a degenerative lesion of the axons, a lesion with rupture of axons and intraneural scarring, and a complete rupture of the nerve root, are identical Early operation is often advised in order to discover the exact nature of the lesion but unless the nerve roots are ruptured, which as we have seen is infrequent, there is nothing to be gained If the nerve is in continuity it is quite impossible by naked-eye examination to give a satisfactory prognosis

The lesion is always supraclavicular and the most common situation is in the roots, somewhere between the intervertebral foramina and the point where the roots join to form the three main trunks. Signs pointing to a high lesion of the fifth and sixth roots include paralysis of the diaphragm, rhomboids, and serratus anterior, and in the first thoracic root, Horner's syndrome. In this series, signs of a high lesion were present in seven out of forty traction injuries of the upper roots, and in fifteen out of thirty traction injuries of the first thoracic root.

Pain may be an early and distressing symptom. It is usually most persistent in severe traction lesions of the lower roots of the plexus and it is an unfavourable prognostic sign. Oedema is always a troublesome feature when paralysis is extensive and, unless prevented by prompt and energetic treatment, it causes rapidly increasing stiffness of the joints.

TABLE I

Analysis of Recovery in Lesions of C 5, 6, 7 Roots

Roots involved	Number of cases	Satisfactory functional recovery		Incomplete recovery	No recovery
		Within six months	Over six months		
3 4 5	1	—	1	—	—
4 5	2	1	1	—	—
3 4, 5 6	1	—	—	—	1
5 6	10	4	4	1	1
3 4 5 6 7	1	—	1	—	—
4 5 6 7	1	—	—	—	1
5 6 7	17	4	6	6	1

PROGNOSIS

Perusal of the surgical literature leaves one with the impression that most traction injuries of the plexus are hopeless surgical problems. So gloomy a view is not supported by this survey, for many lesions of the plexus recovered satisfactorily provided only that meticulous attention was given to the details of conservative treatment.

Non-degenerative lesions of the plexus always recover quickly and completely. They are distinguished easily from degenerative lesions by persistence of normal electrical reactions for longer than eighteen days after injury and by absent, or no more than patchy, sensory loss in the areas normally innervated by the damaged nerve roots (Seddon 1943). In this series, thirteen of the sixty-three injuries of the plexus could be described as non-degenerative lesions and, as one would expect, they were more common when the damage was confined to C 5, 6 nerve roots.

In degenerative lesions the pattern of recovery was fairly constant; lesions of C 5, 6 recovered well, whereas some residual palsy was inevitable in lesions of the whole plexus. The prognosis of lesions of the upper roots of the plexus was not influenced by the level of the lesion, nor by involvement of the third and fourth cervical nerves in addition to the main roots of the plexus (Table I).

Lesions of C 5, 6 nerve roots—There were fourteen patients with lesions of C 5, or C 5, 6 roots (Table I). Eleven patients regained flexion of the elbow, abduction of the shoulder, and external rotation of the shoulder, against gravity and resistance, though not all were capable of sustained effort. Two cases were rated as failures although, in fact, the follow-up

period was not sufficient for final assessment In one patient there was incomplete recovery in the flexors of the elbow joint In all cases rated as satisfactory, weak contraction was noted in the paralysed muscles within nine months of injury

Lesions of C 5, 6, 7 nerve roots—In so far as lesions of C 5, 6, 7 are usually caused by greater violence, the results of conservative treatment are less satisfactory than in lesions of C 5, 6 (Table I) Even so, eleven of the nineteen patients in this group regained extension of the wrist and fingers, flexion of the elbow, and abduction of the shoulder against gravity and some resistance In six patients there was incomplete recovery of function in the paralysed muscles, and two were failures

The residual paralysis in the six incomplete recoveries was interesting Half the patients had residual paralysis of the abductors and external rotators of the shoulder, these injuries of the plexus were apparently caused by forcible depression of the shoulder with the limb by the side The other three patients had residual paralysis of the extensors of the wrist and fingers, the plexus injury being caused by the abducted limb being forced behind the trunk (Fig 2)

Illustrative case—*J D aged 19 years* was struck on the left forearm by a heavy piece of stone during an air-raid The arm was forced backwards and outwards and there was immediate paralysis and numbness of the whole limb On admission to hospital examination revealed a fracture of the left radius, and a traction injury of the C 5 6 and 7 roots Within six months of injury there was good recovery in all the paralysed muscles with the exception of those innervated by the seventh cervical nerve root, and in these muscles paralysis was permanent

Traction injuries of C 5, 6, 7 were usually mixed lesions and the time of reappearance of voluntary power in the paralysed muscles varied considerably The flexors of the elbow often recovered within two months of injury Satisfactory recovery was possible in the deltoid even when voluntary contraction was first noticed thirteen months after injury

Lesions of the whole plexus—There were four non-degenerative lesions of the whole plexus and all recovered completely within six months of injury In the other twenty-four cases the patient had either permanent paralysis of all muscles of the limb, or incomplete recovery in the muscles innervated by the upper or lower roots of the plexus (Table II)

TABLE II

ANALYSIS OF RECOVERY IN TWENTY-EIGHT LESIONS OF THE WHOLE PLEXUS

Degree of recovery		Number of cases	Cases with Horner s syndrome	Cases with severe pain	Remarks
Complete recovery		4	—	—	All were non-degenerative lesions Complete recovery within six months
Incomplete recovery	(a) Upper roots	7	6	5	First sign of recovery in muscles innervated by C 5, 6 roots noted at six to fifteen months from the date of injury
	(b) Lower roots	10	—	2	Complete recovery of muscles innervated by C 8 T 1 roots within two months of injury
No recovery		7	7	4	—

Horner's syndrome is always a grave prognostic sign It indicates irreparable injury of the lower roots and often of the whole plexus Thirteen of these patients had Horner's syndrome, seven were left with permanent total paralysis of the upper limb, and six regained useful voluntary power in the abductors of the shoulder and flexors of the elbow, but no

recovery in any muscle of the forearm or hand The first sign of recovery in the muscles of the shoulder girdle was observed at intervals varying from six to fifteen months

The ten cases without Horner's syndrome were, with one exception, mixed lesions of the plexus Sensation was often unimpaired in C 8, T 1 dermatomes The flexor muscles of the forearm and the intrinsic muscles of the hand recovered completely within a few weeks of injury, leaving the patient with residual paralysis of the muscles innervated by the upper roots of the plexus

Lesions of C 7, C 8, T 1—In the whole series there were only two lesions of C 7, C 8, T 1 roots There was no recovery in the one patient who had a Horner's syndrome, the other had a transient lesion of C 7 root, and a degenerative lesion of C 8, T 1 roots, which did not recover

TREATMENT

Preventing joint stiffness—In neglected injuries of the brachial plexus, contracture of the joints often causes more disability than muscular paralysis Oedema is proportionate to the severity of injury, and it is the main cause of joint stiffness, it must be prevented by elevating the limb, usually on an abduction splint All joints should be put through a full range of movement several times a day Fractures may prevent full movement of the shoulder joint, but on no account should movements of the wrist and digits be neglected

Preventing muscle wasting—Continuous stretching of the paralysed muscles is prevented by appropriate splinting If opposing groups of muscles are paralysed, the mid-position of the joint is chosen Daily galvanic stimulation will prevent excessive wasting of the paralysed muscles During the phase of recovery it is essential to re-educate all muscles which are showing feeble voluntary contraction Prolonged treatment may be necessary, and it is important to allow sufficient time for recovery before considering reconstructive operations In degenerative lesions of the upper roots, the first sign of recovery may not be observed until at least twelve months after injury

Relief of pain—In some cases pain is very distressing It may be relieved by elevating the limb so that the injured roots of the plexus are not under tension As a rule, pain subsides slowly over a period of several months Only two operations were performed in this series for persistent pain One, a patient aged twenty-eight years, complained of severe pain three years after a traction injury of the whole plexus, cervical sympathectomy was performed without success The other patient, aged fifty years, complained of severe pain four years after irreparable injury of the plexus In this case the pain was relieved by amputation and exploration of the plexus

Operative treatment—There is still much difference of opinion as to the indications for operative treatment in traction lesions of the plexus Jefferson (1930), advocated operation within ten days of the injury, or not at all His purpose was to determine the extent of the lesion and he believed that primary suture might sometimes be feasible in rare cases where two clean nerve ends were discovered in an accessible position Recently Davis, Martin, and Perret (1947) have stated " that the best possible results following brachial plexus injuries may be obtained by operation as soon as the acute effects of injury to the soft parts have subsided," and the same authors even advocate exploration of old injuries of the plexus

We have to consider then 1) whether early exploration of the plexus is indicated in order to assess the prospects of recovery, or on the off-chance that operative repair of the damaged nerves may be possible, 2) the indications, if any, for late exploration of neglected injuries The decision presents no difficulty when lesions are confined to the upper three roots of the plexus, for recovery is usually so satisfactory that operative treatment need hardly be considered

Since only three lesions of the whole plexus were explored within three months of injury there was no direct evidence as to the value of early exploration in assessing the prospects of recovery in these cases We have seen, however, that it is possible to give a fairly accurate

prognosis on clinical data alone, and it is unlikely that early exploration of the plexus could give more information, apart from the rare occasions when rupture of the roots is disclosed

It could be argued that the prognosis in lesions of the whole plexus is so bad that it is reasonable to attempt any form of repair of the damaged roots, no matter how unpromising it may seem Lesions complicated by Horner's syndrome are not now, and probably never will be, amenable to surgery, for the lesion of C 8, T 1 roots is so high as to make any type of repair impossible Lesions without Horner's syndrome are a little more promising In these the upper roots sustain the brunt of injury, and one can with some confidence look forward to useful recovery in the muscles of the forearm and hand If the upper trunk of the plexus is attenuated or swollen, there need be no hesitation in resecting the damaged part of the nerve The main difficulty is that the lesion is not always accessible and that, even if it is, primary suture is impossible after adequate resection The gap might be bridged by suitable autografts but the number of cases in which grafting is feasible will be few, and it has still to be proved that functional recovery after grafting is as satisfactory as the results of late reconstructive surgery Seddon (1947) reported one incomplete recovery and two failures in three autogenous cable grafts for traction lesions of C 5, 6 roots The failures were ascribed to inadequate resection

Late exploration of the plexus and freeing of nerves from scar tissue may occasionally be justified for the relief of pain which has not responded to conservative treatment It cannot assist recovery because the chief barrier to regeneration is the endoneural scar

When the full extent of recovery is known the function of the limb can often be greatly improved by reconstructive surgery Such operative measures should not be considered rlier than fifteen months from the date of the accident, because recovery in the proximal scles of the limb has been observed more than one year after injury

SUMMARY

1 Sixty-three traction injuries of the brachial plexus in adults are reviewed Most of the patients were seen at regular intervals for more than three years after injury

2 The mechanism of injury is described Forcible separation of the head and shoulder is the essential factor, but the type of lesion is determined by the position of the upper limb at the time of the accident

3 In traction injuries the main damage is intraneural, and the lesions are of considerable extent Extraneural scarring is a conspicuous feature of old injuries, but it does not cause any damage to uninjured parts of the plexus

4 The prognosis of each type of lesion of the plexus is discussed Satisfactory recovery occurs in most lesions of the upper three roots Degenerative lesions of the whole plexus never recover completely Cases with Horner's syndrome always have severe residual paralysis

5 Conservative treatment is advocated for traction injuries of the plexus and evidence is cited against early or late operations on the plexus Reconstructive surgical procedures are sometimes indicated

I am indebted to the staffs of the Peripheral Nerve Injury Centres at Killearn Oxford, and Winwick for the detailed case records of the traction injuries of the brachial plexus which have formed the basis of this investigation, and especially to Mr A R Parkes Mr H J Seddon, and Mr R Roaf The illustrations are the work of Mr G Donald of the Department of Surgery, Glasgow University

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OPEN WOUNDS OF THE BRACHIAL PLEXUS

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Of the peripheral nerve injuries treated at the Wingfield-Morris Orthopaedic Hospital, Oxford, between 1940 and 1945, it was found that 52 per cent of the first 1600 cases were due to penetrating wounds The brachial plexus was damaged in forty-two of these 820 cases, namely, 6 per cent —a proportion which corresponds closely with that recorded after the first World War by Lehmann (1921) Oppenheim (1923) and Pollock (1926) Isolated high lesions of the median, radial, and ulnar nerves are excluded from this study

The conspicuous lack of information available in the literature may be due to difficulties of analysis, the intricacy of the plexus, anatomical variations, and the bizarre motor and sensory changes that may occur after injury Pollock and Davis (1933), and other authors, concentrated on the problem of precise localisation of the lesion rather than on that of functional recovery of the limb In any given case the damage is seldom uniform and a mixture of neurapraxia, axonotmesis, neurotmesis, and more or less undamaged nerve fibres, is common

In dealing with degenerative lesions of other peripheral nerves after penetrating wounds there is now little doubt as to the policy that should be adopted, exploration is the rule (Seddon 1948) Does this principle apply to exploration of the brachial plexus? Operations have been described by which the plexus may be exposed throughout its length (Platt 1924, Stiles and Forrester-Brown 1922), but in what proportion of cases is division of nerves likely to be found? Is repair at this level a practical procedure? Are the results of repair such as to justify it? If the proportion of divisions is small and, still more, if repair at this level is not worth while, is exploration useful only in prognosis? The object of this paper is to answer such questions in the light of experience gained at the Oxford centre during the second world war

METHODS OF ANALYSIS AND OF RECORDING THE RESULTS OF TREATMENT

Forty-two cases in which the brachial plexus was damaged by penetrating wounds have been examined In many of them paralysis was at first complete, but rapid recovery occurred in part of the plexus within a few weeks, leaving residual paralysis which was slow to disappear and from which recovery was often imperfect All patients were treated by electrical stimulation of the paralysed muscles until voluntary control was restored or until it became evident that no recovery would occur (Jackson 1945) Observations were continued for at least two years after injury and in many cases for three or four years

In order to compare cases a specific method of grouping, and of grading recovery, has been adopted (Fig 1)

Group I —Lesions of the roots and trunk of C 5, 6
Group II —Lesions of the posterior cord
Group III—Lesions of C 8, T 1, and the medial cord

In many cases the lesion involves more than one group, and when injuries involve the whole plexus the grade of recovery is necessarily expressed as a threefold statement

Paralysis in Group I (deltoid, spinati, biceps, brachialis, brachio-radialis, and extensor carpi radialis longus) causes loss of abduction and external rotation movement at the shoulder joint, and loss of flexion movement at the elbow Recovery is expressed in terms of ability to perform these movements, muscle power being graded in accord with the

system recommended by the Nerve Injuries Committee of the Medical Research Council The power of abduction is represented thus

Paralysis	A 0
Flicker	A 1
Movement with gravity eliminated	A 2
Movement against gravity	A 3
Movement against gravity and resistance	A 4
Full power	A 5

The power of external rotation at the shoulder, and of flexion at the elbow, are expressed similarly, the figures being prefixed by E and F respectively Sensory recovery after lesions of C 5, 6 is relatively unimportant and will not be discussed

Paralysis in Group II (the posterior cord) gives rise, for the most part, to loss of power of the deltoid, teres major, latissimus dorsi, subscapularis, triceps, and the forearm extensors Recovery is expressed thus

Triceps contracting against gravity	P 1
Extensors of the wrist contracting against gravity	P 2
Extensors of the fingers contracting against gravity	P 3
Extensors of the thumb contracting against gravity	P 4
Full recovery	P 5

Here again sensory function, being unimportant, is left out of account

Paralysis in Group III (C 8, T 1, and medial cord)—Recovery is expressed in terms of the distribution of median and ulnar nerves This method is anatomically inexact in so far as the proximal muscles supplied by the median nerve derive part of their innervation from the lateral cord Nevertheless, no significant errors could be traced to this compromise, and any attempt to refine the analysis would have made a difficult task almost impossible The grading is that adopted by the Medical Research Council

Sensory Recovery

No recovery of sensibility in the autonomous zone of the nerve	S 0
Recovery of deep cutaneous pain sensibility in the autonomous zone of the nerve	S 1
Recovery of superficial pain sensibility	S 1+
Recovery of superficial pain and some touch sensibility	S 2
Recovery of superficial pain and touch sensibility but with over-reaction and inability to localise the stimulus	S 2+
Recovery of pain and touch sensibility with disappearance of over-reaction or with the appearance of some ability to localise the stimulus	S 3
Recovery to S 3 with good localisation & some recovery of two-point discrimination	S 3+
Complete recovery	S 4

Motor Recovery—Median nerve

No contraction	M 0
Contraction in the proximal muscles but not against gravity	M 1
Proximal muscles acting against gravity no return of power in thenar muscles	M 1+
Proximal muscles acting against gravity and a flicker in the thenar muscles	M 2
Proximal and thenar muscles acting against resistance	M 3
All muscles acting against strong resistance with some independent action	M 4
Full recovery in all muscles	M 5

Motor Recovery—Ulnar nerve

No contraction	M 0
Contraction in the proximal muscles but not against gravity	M 1
Proximal muscles acting against gravity, no return of power in intrinsic muscles	M 1+
Proximal muscles acting against gravity, some power in the hypothenars and little or none in the interossei	M 2
Proximal and intrinsic muscles all acting but the first dorsal interosseous unable to act against resistance	M 2+
Proximal muscles hypothenars & 1st dorsal interosseous acting against resistance	M 3
As in Grade 3 but with some independent lateral movement of fingers	M 4
Full recovery in all muscles	M 5

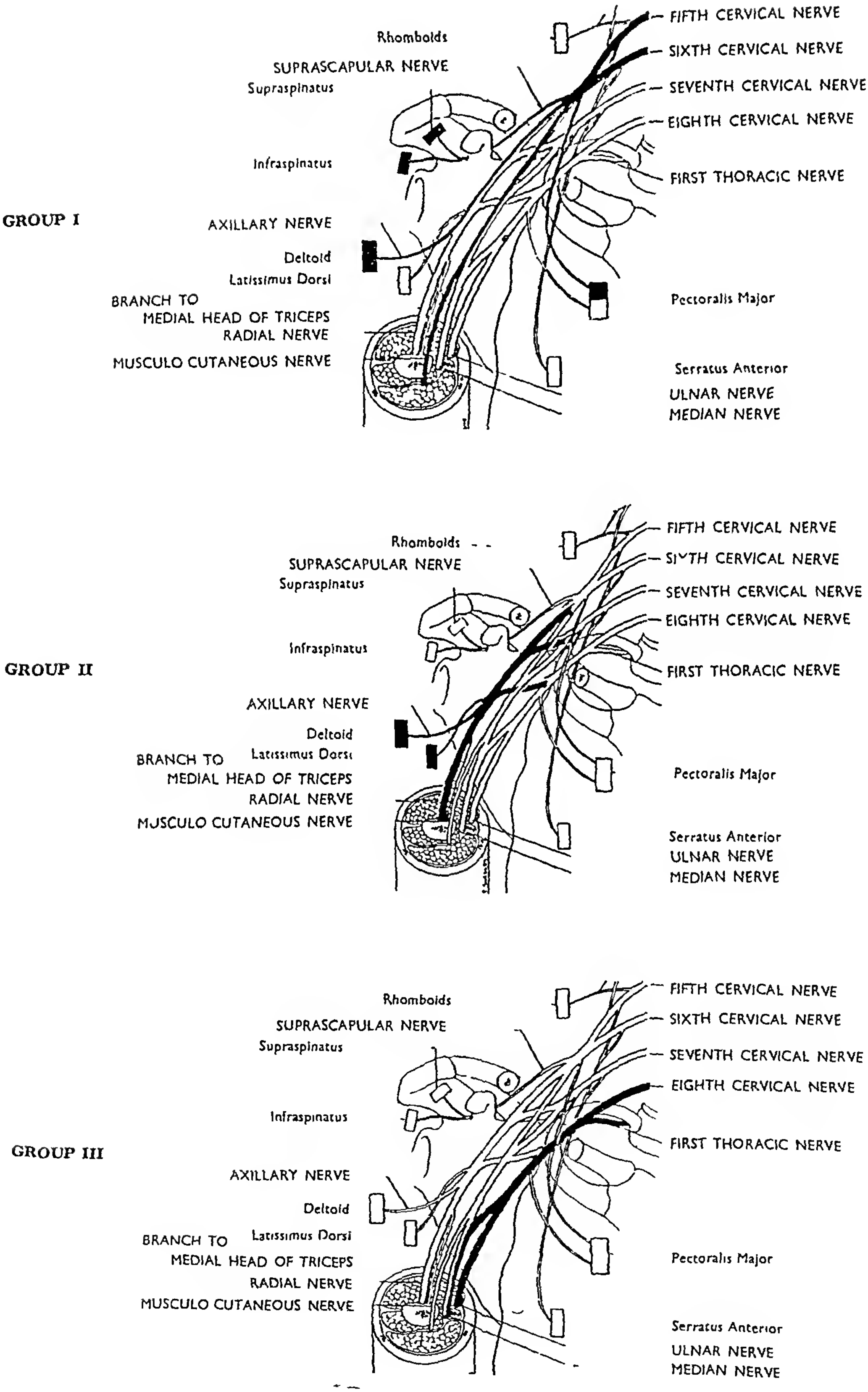

FIG 1

Diagrams illustrating the three groups of nerve lesions
(*Modified after C Shepley—Medical Research Council Memorandum on Peripheral Nerve Injuries* 1943)

TABLE I

ANALYSIS OF RECOVERY IN THIRTEEN CASES WITH LESIONS CONFINED TO THE ROOTS AND TRUNK OF C 5 6

Case No	Date of injury	Sensory loss	Explored		Time in months from date of injury 3	6	9	12	15	18	24	36	Reconstructive surgery
B 113	Aug 43	None	—	A		0	1	1−	2	2	2−	3	—
				E		0	2−	2	2	2	2		
				F		1−	1−	2−	2−	2+	2−		
D 58	June 44	C 4 5	—	A	0	4	4	4	4−				—
				E	0	3−	3−	4	4−				
				F	0	4	4	4	4				
D 63	Aug 44	C 6	—	A	0	2−	4	4	4	4	4		—
				E	1	2−	4	4	4	4	4		
				F	2	3	3−	4	4	4	4		
D 14	July 41	None	—	A		0	2	4	4	4			—
				E		0	2	3	3	3			
				F		2	3−	4	4−	5			
H 95	June 44	C 5 6	—	A	0	1	1	2+	4	4	4		—
				E	0	0	0	2	2−	2+	2−		
				F	2	2−	2−	3−	4+	4−	4−		
H 115	Sept 44	C 5 6 7	—	A	0	2	2−	3	3−	4			—
				E	0	0	1	2	3	3			
				F	0	0	2	3	3−	4			
K 23	Jan 44	C 5 6	—	A	0	0	1	2	3−	3−	4	4	+
				E	0	0	0	0	2	3	3	2	
				F	0	1	2	2−	3−	3−	4−	4−	
L 62	Dec 44	C 4 5	—	A	3	4	4	4	4	4			—
				E	3−	4	4	4	4	4			
				F	4	5	4	4	4	4			
R 36	Apr 43	Circumflex	—	A	0	0	1−	2+	2−	4+	4−	4−	—
				E	0	0	1	2	3	3	3	4+	
				F	1	2−	3	3+	3+	4+	4−	4+	
S 58	June '42	None	—	A	0	3	3	3	4	4	4+	4+	—
				E	0	3+	3+	3+	3−	3−	4	4+	
				F	3	3+	3−	3+	4	4	4	4+	
T 23	Mar 42	None	—	A	2	4+							—
				E	2	4							
				F	3+	4+							
V 11	Apr 44	C 5 6	—	A	2	2	4	4	4+				—
				E	2	2	3	3−	4+				
				F	2	2	3	3	4+				
Z 23	Sept '44	C 5, 6	—	A	0	3	3+	4	4	4+	4+	4+	—
				E	0	0	3+	4	4	4	4	4	
				F	2	3	4	4	4	5	5	5	

Group I (a)—Lesions confined to the roots and trunk of C 5, 6 (Table I)—In thirteen patients the lesion was confined to the roots and trunk of C 5, 6 In only two was there complete motor and sensory paralysis, in eleven there was sparing, more or less, of either motor or sensory function The good recovery which occurred is shown in Fig 2 After two years, flexion of the elbow was possible against both gravity and resistance in all cases but one, abduction of the shoulder against gravity was also regained in all cases except this one, and external rotation of the shoulder against gravity was possible in all cases but two Five operative explorations were made and in none was repair deemed necessary because the nerves were in continuity and it appeared that they were not damaged seriously In two cases there was a history of wound infection which appeared to have no significant influence on the recovery With one exception, the final result was good in all cases which showed evidence of motor recovery at nine months from the time of injury

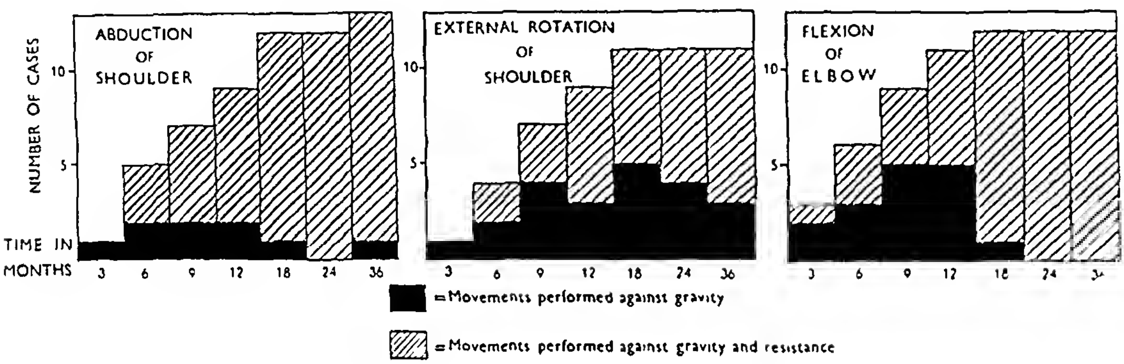

FIG 2

Histogram showing the progress of recovery in thirteen cases in which the lesion was limited to C 5 and 6

Group I (b)—The C 5, 6 component in extensive lesions of the plexus (Table II)—Analysis of fifteen other cases with more extensive lesions of the plexus showed again that recovery was remarkably good (Fig 3) Six of these had, at first, complete motor and sensory loss The others, as in Group I (a), showed some sparing in either motor or sensory function Nine explorations were made and in only two instances was there division of nerves

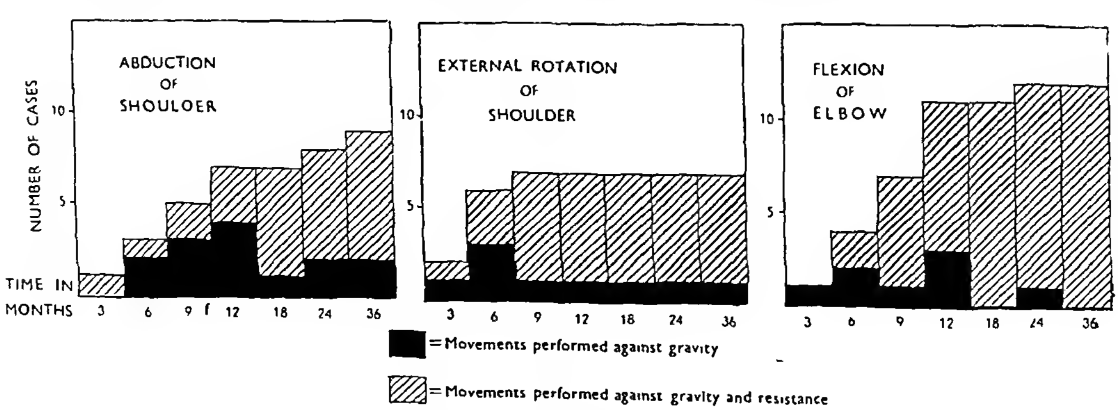

FIG 3

Histogram showing the progress of recovery in the C 5, 6 component in fifteen cases of more extensive lesions of the brachial plexus

Group II—Lesions of the posterior cord (Table III)—There were twenty-one patients with injury of the posterior cord of the plexus, but only in one was there no other damage This man was first seen two years after injury and he was kept under observation for one year more, by which time there was recovery only in the triceps In twenty patients the injury

TABLE II

Analysis of Recovery of the C 5, 6 component in Fifteen Cases of Extensive Lesions of the Plexus

Case No	Date of injury	Sensory loss	Vascular injury	Explored		3	6	9	12	15	18	24	36	Reconstructive surgery
B 164	Aug 44	None	−	−	A	0	2	3						−
					E	0	3	4						
					F	2	4	4+						
B 195	Mar 45	Complete plexus	−	+	A	0	0	2	3+	4	4	4+		−
					E	0	0	0	2	2	2	2		
					F	0	1	2+	4	4	4	4+		
B 171	Sept 44	C 7	−	+	A	4+	4+	4−	4+	4−	4+			−
					E	5	5	5	5	5	5			
					F	0	0	1	3	4	4			
C 134	Oct 44	C 5 6	−	−	A	0	1	2	3	3−	4			+
					E	0	0	2	2	2	2			
					F	2	3	4	4+	4+	4+			
H 107	May 44	Below elbow	−	−	A	2+	3+	3+	3+	4				−
					E	2	3	3	3	3				
					F	3	4	4	4	4				
K 7	June 41	C 5 6 7	−	+	A	0	0	3	4+					−
					E	0	3	4	4					
					F	0	2	4	5					
K 8	July 41	C 5 6 7	−	+	A				0	1	1+	2	2+	−
					E				0	0	0	0	0	
					F				0	0	0	0	0	
L 43	Oct 43	C 8 T 1	+	−	A		3	4+						+
					E		5	5						
					F		3	4						
M 101	Sept '44	C 5, 6	−	+	A		0	1	1	1	2+	4		+
					E		4	4	4	4	4	4		
					F		2	4	4	4	4+	5		
P 38	Jan 43	Complete plexus	−	−	A		0	0	0	1	2	2+	3+	−
					E		0	0	0	1	1	2	2	
					F		0	0	0	1	1	2	2	
P 59	Sept 43	C 5 6	−	+	A	0	0	0	0	0	0	0	0	−
					E	3+	3+	4	5	5	5	5	5	
					F	0	1	3+	4	4	4	4	4	
S 158	Feb '45	C 4 5 6	−	+	A	0	2	2+	2+	2+	2+	2+		+
					E	0	0	0	0	0	0	0		
					F	0	0	2	3+	0	4	4		
S 143	June '44	C 5	+	−	A	0	0	0	0	0	0	0	0	−
					E	0	0	0	0	0	0	0	0	
					F	0	0	0	0	1	1+	3	4	
W 102	June 44	Complete plexus	+	+	A	0	0	1+	2	2	2	2		+
					E	0	0	0	0	0	0	0		
					F	0	0	2+	3+	4	4	4		
H 113	June 44	C 5 6 7	−	+	A	0	0	0	2	2+	2+	3	4	−
					E	0	0	0	0	0	2	2	2	
					F	0	0	0	2	3	3+	4	4	

also involved the medial cord, or the whole of the remainder of the plexus, in roughly equal proportions The behaviour of the posterior cord was much the same in all, and no separate analysis is necessary Over half of these twenty cases reached Grade 4 within two years of the date of injury, that is to say there was ability to extend the thumb against gravity Almost three-quarters of them reached Grade 3 (Fig 4) Where there was no evidence of recovery in the triceps within nine months of injury the prognosis was usually poor, and it was always so if there was no recovery within a year Patients who were kept under observation for more than two years showed no significant change

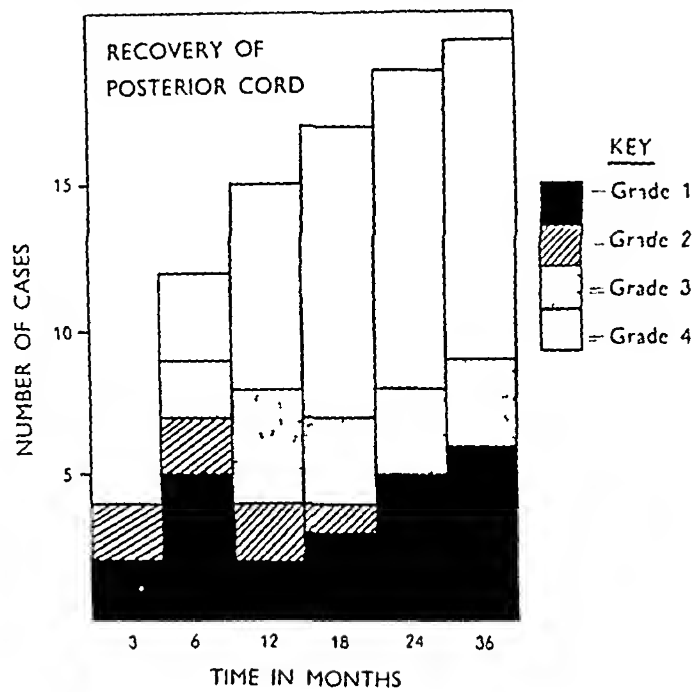

Fig 4

Histogram showing the progress of recovery in twenty-one cases of injuries of the posterior cord

Group III—Lesions of C 8, T 1, and medial cord (Table IV)—Twenty-five cases are considered in this group This number included eleven in which the whole plexus was involved five in which the lesion was confined to the medial cord, six in which the posterior and medial cords were affected, and three in which the upper trunk and medial cord were damaged The progress of recovery in these subdivisions showed no significant differences When there was complete motor paralysis at six months in either the median or ulnar nerve distributions (axonotmesis or neurotmesis of the relevant segment), and no evidence of motor recovery in the proximal muscles by one year, the outlook was very poor The best recovery after axonotmesis was seen in case K 5 after two years, recovery was M 4, S 3, in the median nerve distribution This case is of special interest median paralysis occurred after the development of a traumatic aneurism of the axillary artery, when the plexus was explored four months after injury no macroscopic lesion of the medial cord or of its branches could be detected, in other words, the lesion must have been a pure axonotmesis due to compression by the aneurism This case was the only one in which material recovery took place in the distal muscles after a complete degenerative lesion, presumably because none of the fibres had suffered such permanent damage as almost always occurs after penetrating wounds In those cases in which it was possible to continue observations for a longer period there was no significant improvement in motor function between the second and third years, but in some the quality of sensibility continued to improve up to four years from the time of injury Sensory sparing does not carry with it a guarantee of adequate motor recovery, a finding that was emphasized by Pollock (1926) and which has been confirmed repeatedly in this series

TABLE III

Analysis of Recovery in Twenty-one Cases of Lesions of the Posterior Cord

Case No	Date of injury	Sensory loss	Vascular injury	Explored	Time in months from date of injury						Recon-structive surgery
					3	6	12	18	24	36	
B 164	Aug 44	None	–	–	1	5					–
B 132	Nov '42	None	–	–					1	1	–
B 195	Mar 45	Complete plexus	–	–	0	0	0	0	1	1	–
C 134	Oct '44	C 5, 6	–	–	1	1	2	4	4	4	+
F 47	Feb 44	Ulnar distribution	+	–	0	1	4	5			–
H 113	June 44	C 5, 6 7	–	+	0	0	0	0	0	1	–
H 36	Aug 42	Radial and ulnar distribution	+	+	0	2	3	3	3	3	–
H 2	Nov '40	C 8 T 1	–	+	2	3	4	4	4		–
K 7	June 41	C 5, 6 7	+	+	2	3	4				–
K 8	July 41	C 5 6 7	–	+	0	0	0	1	1	1	–
L 65	Feb '45	C 5 6	+	+	0	1	3	4	4		–
L 43	Oct '43	Almost complete plexus	+	–	0	0	3	4	4	4	+
Mc 24	June 44	None	–	–	0	4	5				–
M 26	June '44	Complete plexus	+	+	0	1	3	3			–
M 101	July '44	C 5 6	+	+	0	0	1	1	1	1	+
P 47	Jan '43	Sparing posterior cord only	+	+		3	4	4	4	4	–
P 38	Jan '43	Complete plexus	–	–	0	0	0	0	0	0	–
P 59	Sept 43	C 5 6 complete C 7 8 T 1 incomplete	–	+	0	0	1	2	3	3	–
S 158	Feb '45	C 4 5, 6	–	+	0	4	5				+
S 104	Aug 43	C 8 T 1	–	+		2	2	3	4	4	–
W 102	June 44	Complete plexus	+	+	0	0	0	1	1	1	+

EXPLORATION OF THE PLEXUS

In twenty-two patients operative exploration of the plexus was undertaken because there was a severe lesion involving the whole plexus, a complete lesion of a localised part of the plexus such as the upper trunk, or persistent pain in the limb (Table V) In no case was it considered justifiable to resect a lesion in continuity, and in only four was a nerve found to be divided, repair being possible in three There was an average delay of six months between the time of injury and operation, the earliest exploration being at one month, and the latest at thirteen months At the time of exploration incidental " neurolysis " was of course inevitable but there was no substantial evidence that recovery was influenced by such neurolysis, though in one case it did relieve persistent pain in the limb In general, scarring was severe and it was not always possible, or at any rate safe, to expose the entire plexus For this reason, nerve trunks which were actually seen are specified in the accompanying table The most severe scarring was seen in two cases in which there were aneurisms of the axillary artery, and both made good recoveries

Types of lesion—Exploration of the nerves showed 1) no obvious change, 2) " degenerative appearance " of the nerve—a grey-pink translucent appearance which is characteristic and may be due to the disappearance of myelin (when no neuroma was found this appearance was presumed to indicate axonotmesis), 3) nerve enveloped in scar tissue, with or without evidence of constriction, 4) neuroma—(*a*) fusiform, hard or soft, (*b*) lateral, 5) interruption of continuity Intraneural scarring was never found by itself, in every case it was seen in association with a neuroma

Correlation of operative findings with recovery observed after two years from the time of injury—1) *No obvious damage*—On eight occasions the part of the plexus exposed showed no evidence of abnormality, yet in only half these cases was recovery good In one instance, however, it is likely that the lesion was distal to the field of exploration

2) *Degenerative appearance of the nerve*—In four cases part of the plexus showed degenerative changes, and in two there was proximal thickening of the nerve without neuroma formation These were presumed to be examples of axonotmesis, and the favourable prognosis which was given was justified subsequently in so far as re-innervation of the proximal muscles was concerned Nevertheless recovery in the distal muscles was consistently poor and it was never of functional significance

3) *Enveloping scar*—Where extensive scarring surrounded part of the plexus, and there was no other evidence of injury, recovery was good except in one case where a vascular lesion caused ischaemic damage of nerves and muscles

4) *Neuromata—a) Fusiform neuroma*—On two occasions a fusiform neuroma was seen and there was good recovery in the affected segment of the plexus In two cases where a hard neuroma was found, one on the posterior cord and the other on the root of C 7, recovery was very poor In one case there were three soft neuromata, on the posterior and lateral cords and on the lateral root of median, and fair recovery took place in each segment *b) Lateral neuroma*—In four cases a lateral neuroma was discovered In two, recovery was poor, on the other hand recovery was good in one case in which the neuroma appeared to involve two-thirds of the nerve

5) *Neurotmesis*—In only four cases was there interruption of continuity Repair was possible in three In one, the upper trunk was divided, suture was performed and, after two years, recovery of flexion at the elbow against gravity and resistance was possible but abduction and external rotation of the shoulder were weak In the second case, branches of the upper trunk were found to be divided After resection of proximal and distal stumps it was impossible to restore continuity by direct suture, and three grafts were taken from the medial cutaneous nerve of the forearm as it traversed the upper arm, no certain evidence of regeneration through the grafts was found three years after operation In the third case, the inner and outer heads of the median nerve were divided After resection, the gap measured

six centimetres and suture was possible only after mobilisation of the median nerve as far distally as the cubital fossa, with sacrifice of the branches to pronator teres, recovery in the median area at three years was M 1, S 2+ In the last case, the lateral cord was divided together with the medial head of median nerve In searching for the peripheral stump of the median nerve it proved necessary to extend the dissection fifteen centimetres below the coracoid process There was no obvious explanation for this wide gap unless possibly the nerve trunk had been removed inadvertently at the time of the original wound excision (though it is to be noted that Scaglietti (1942) suggests that excessive retraction of the distal stump may occur in consequence of the weight of the limb when part of the plexus is divided)

DISCUSSION

The most striking feature of these explorations has been the comparatively few occasions on which there has been division of nerve tissue—no more than four instances in a series of twenty-two operations This is in sharp contrast with the degenerative nerve lesions which occur more distally in open wounds, where experience has shown that one in every two cases is associated with nerve division (Seddon 1948)

Closure of the gap after resection is not easy In only one case, with injury of the upper trunk, was such closure possible without extensive mobilisation of the distal stump In a second case a nerve graft was used, and in a third, mobilisation of the median nerve as far as the elbow joint was necessary In all three of these cases the degree of recovery was discouraging

As in other nerve injuries at a high level—for example, proximal injuries of the sciatic nerve—if there is to be good functional recovery, early repair is imperative Ferron (1919), reporting operative findings in two early explorations of the plexus, remarked " que les symptômes paralytiques ne sont pas toujours en rapport avec les lesions macroscopiques constatees lors de l'operation " This compares unfavourably with the relatively accurate correlation between operative findings and prognosis in other nerves (Seddon 1943, 1948), and our experience of early and late explorations is much the same In every case the plexus was stimulated electrically and, if this showed conduction in part of the nerve, no more was done Unfortunately such stimulation gives little information as to the exact pathology of a nerve lesion, and in early explorations negative findings are valueless Thus axonotmesis, and severe intraneural scarring amounting to neurotmesis, cannot be distinguished Trial section, a valuable aid in more distal lesions, is technically difficult on account of lack of mobility of the plexus and the consequent difficulty in inspecting a small transected area Moreover, there is reason to believe that naked-eye appearances of nerve sections at this level are less reliable than elsewhere Ancillary methods, which are usually so valuable in deciding for or against resection of a neuroma, are therefore of little application in this region where they are most needed

From these exacting and time-consuming operations the dismal conclusion must be reached that a reliable prognosis cannot be given except in those few cases where a nerve trunk is found to be divided, or where there is a hard neuroma—an indication that the greater part of the nerve is blocked permanently In axonotmesis, the conditions for recovery are the best possible the stroma of nerve is preserved to a large extent, and the outgrowing axons remain in their appropriate Schwann tubes Recovery then depends only on the distance between the lesion and the periphery it is no more than a matter of time In the upper trunk, and in the posterior cord, the distance from the site of damage to the denervated muscles is relatively short, but in the medial cord the distance to the muscles of the hand is much greater Is delay, even in axonotmesis, an adverse factor? Apparently it is, for recovery in Groups I and II was consistently better than in Group III

The harmful influence of delay on the recovery of motor function is due to shrinkage of the empty Schwann tubes, atrophy of muscle fibres, interstitial fibrosis, and disappearance

of motor end-plates (Holmes and Young 1942, Gutmann and Young 1944, Bowden and Gutmann 1944) It is possible, though not clearly established, that the effect on sensory regeneration may be similar It was shown, however, by Simpson and Young (1945) that the small size of Schwann tubes at the periphery may be less significant than was at first believed, and it has been assumed increasingly that muscle atrophy was the more important factor Gutmann and Guttmann (1942) proved that, in the rabbit, regular intensive galvanic stimulation could be relied upon to a remarkable degree in preventing atrophy of denervated muscle and maintaining its normal state as determined histologically That such treatment is valuable in clinical practice, particularly in the small muscles of the hand, has also been demonstrated by Jackson (1945) Useful return of power in the intrinsic muscles of the hand might therefore be expected in proximal nerve lesions in which there was prospect of spontaneous recovery, and in which fair recovery did in fact take place in the proximal muscles, provided only that wasting was prevented by regular and adequate galvanic stimulation The fact is, however, that although such treatment is consistently effective in lesions of the ulnar nerve, recovery of function in the small muscles of the hand after injuries of the brachial plexus did not occur except in one case where the *rate* of regeneration was exceptionally rapid We must conclude that shrinkage of Schwann tubes is significant after all, or that the beneficial effects of galvanic stimulation are of limited duration

Results of exploration in C 5, 6 lesions (Groups Ia, Ib)—Good recovery occurred regularly in both divisions of this group In over half the cases, recovery in the biceps preceded that in the deltoid and the external rotators of the shoulder, and on several occasions some action in the biceps was *maintained* where motor paralysis was otherwise complete Moreover, when motor power became stationary, flexion of the elbow was often the most powerful movement of the three This suggests that innervation of the biceps may not always be limited to C 5 and 6—a possibility which gains further support from certain observations 1) On exploration of an extensive lesion of the plexus, with sparing of the deltoid and spinati, the upper trunk was found to be intact, but the root of C 7 was damaged to the extent of one-third of its diameter, the biceps only was paralysed 2) In another case the upper trunk was found to be divided but an apparently intact branch from C 7 joined the distal stump the upper trunk was repaired, recovery in the biceps preceded that in the deltoid and spinati, and, three years after injury, flexion of the elbow was possible against gravity and resistance whereas there was only slight power in the deltoid and no recovery in the external rotators 3) A third case, operated on elsewhere for a surgical condition in the neck, suffered accidental division of the upper trunk which was sutured immediately, action in the biceps against gravity was never lost Thus recovery of the biceps after lesions involving the upper trunk may not necessarily indicate axonal regeneration in the C 5 and 6 component, and may account in some measure for the comparatively favourable reputation which suture of the upper trunk has enjoyed Similarly, the good recovery that usually occurs in lesions in continuity of C 5, 6 does not necessarily prove that a conservative attitude is wholly justified

Results in posterior cord lesions (Group II)—On the whole, recovery in this group was good As in Group I, there are, relatively speaking, no distal muscles to be re-innervated and the length of axonal regeneration is not unduly great

Results in lesions of C 8, T 1, and the medial cord (Group III)—In cases showing complete degenerative lesions, functional recovery was disappointing The distal muscles never regained useful action, occasionally a flicker of contraction or evidence of electromyographic activity showed that some axonal regeneration had taken place, but unfortunately not before secondary changes in the muscles or nerves had prejudiced recovery Even in the presence of reasonably powerful proximal muscles, use of the hand was severely limited, and impaired sensibility was a serious disadvantage In spite of treatment continued for more

TABLE IV

ANALYSIS OF RECOVERY IN TWENTY-FIVE CASES OF LESIONS OF C 8, T 1 ROOTS AND THE MEDIAL CORD

Case No	Date of injury	Vascular injury	Joint stiffness	Explored		Time in months from date of injury: 3	6	12	18	24	36	36+	Reconstructive surgery
L 71	July '44	+	–	–	Ulnar Median			M 1+ S 3+ M 1+ S 4	M 1+ S 3+ M 1+ S 4	M 1+ S 3+ M 1+ S 4			–
M 26	June 44	+	–	+	Ulnar Median	M 0 S 0 M 0 S 0	M 0 S 0 M 0 S 0	M 0 S 0 M 1 S 0	M 0 S 0 M 1 S 1	M 0 S 0 M 1 S 1			+
V 7	Apr 43	–	–	+	Ulnar Median	M 0 S 0 M 1+ S 4	M 0 S 0 M 1+ S 4	M 1 S 0 M 1+ S 4	M 1+ S 0 M 1+ S 4	M 2 S 0 M 1+ S 4	M 2 S 1 M 2 S 4		+
B 164	Aug '44	–	–	–	Ulnar Median	M 1 S 4 M 1 S 4	M 5 S 4 M 5 S 4						–
B 171	Sept '44	–	–	+	Ulnar Median	M 2 S 4 M 1 S 0	M 2 S 4 M 2 S 1	M 2+ S 4 M 2 S 2+	M 2+ S 4 M 3 S 3				–
B 195	Mar 45	–	–	+	Ulnar Median	M 0 S 0 M 0 S 0	M 0 S 0 M 0 S 0	M 0 S 0 M 1 S 0	M 1 S 0 M 1+ S 0	M 2 S 2 M 2 S 2	M 2 S 2+ M 2 S 2+		–
F 47	Feb '44	+	+	+	Ulnar Median	M 0 S 0 M 1 S 3	M 0 S 1 M 1 S 3	M 1+ S 1+ M 2 S 3+	M 2 S 2+ M 3 S 3+	M 2 S 2+ M 3 S 3+	M 4 S 3 M 4 S 3+		–
F 15	Apr '42	–	–	+	Ulnar Median	M 0 S 0 M 0 S 0	M 0 S 0 M 0 S 0	M 0 S 0 M 0 S 0	M 0 S 0 M 0 S 0	M 0 S 0 M 1 S 0	M 1 S 0 M 1 S 0	5 years M 1 S 0 M 1 S 1	–
H 113	June 44	–	+	+	Ulnar Median	M 0 S 1+ M 0 S 1+	M 0 S 1+ M 0 S 1+	M 0 S 1+ M 1 S 1+	M 0 S 1+ M 1 S 1+	M 1 S 2 M 1 S 2	M 1 S 2 M 1 S 2	4 years M 1 S 2+ M 1 S 2+	–
H 36	Aug 42	+	–	–	Ulnar Median	M 0 S 0 M 0 S 0	M 0 S 0 M 1 S 1+	M 1 S 0 M 1+ S 1+	M 1+ S 0 M 1+ S 1+	M 1+ S 1+ M 1+ S 2+	M 2 S 2 M 1+ S 2+	5 years M 2 S 2 M 1+ S 2+	+
H 2	Nov 40	–	–	+	Ulnar Median	M 0 S 0 M 1 S 4	M 0 S 1 M 1+ S 4	M 0 S 1 M 1+ S 4	M 0 S 1 M 1+ S 4			8 years M 2 S 2+ M 1+ S 4	–

H 107	May 44	−	−	−	Ulnar Median	M 2+ S 4 M 2 S 3+	[illegible] S 4 M 2 S 3+	M 2+ S 4 M 2 S 3+	M 2+ S 4 M 3 S 3+	M 2+ S 4 M 3 S 3+	M 2+ S 4 M 3 S 3+		−
K 7	June 41	+	−	+	Ulnar Median	M 4 S 4 M 0 S 0	M 4 S 4 M 0 S 0	M 4+ S 4 M 1+ S 0	M 4+ S 4 M 2 S 2+	M 4+ S 4 M 3 S 3	M 4+ S 4 M 4 S 3		−
K 8	July 41	−	−	+	Ulnar Median			M 4 S 4 M 0 S 0	M 4+ S 4 M 0 S 0	M 5 S 4 M 0 S 0	M 5 S 4 M 0 S 0	4 years M 5 S 4 M 0 S 0	−
L 65	Feb 45	+	+	+	Ulnar Median	M 2+ S 4 M 0 S 3+	M 2+ S 4 M 2 S 3+	M 2+ S 4 M 2 S 3+	M 4 S 4 M 2 S 3+	M 4 S 4 M 2 S 3+			−
L 43	Oct 43	+	+	−	Ulnar Median		M 0 S 0 M 1 S 0	M 1 S 0 M 1 S 0	M 1+ S 0 M 1+ S 0	M 2 S 1+ M 1+ S 1+	M 2 S 2 M 1+ S 2	4 years M 2 S 3 M 1+ S 3	+
M 101	Sept 44	+	+	+	Ulnar Median		M 0 S 1 M 0 S 1	M 1 S 1+ M 1 S 1+	M 1+ S 1+ M 2 S 2+	M 2+ S 2 M 2 S 2	M 2+ S 3 M 2 S 3+		−
N 22	Mar 42	−	−	−	Ulnar Median				M 2+ S 3+ M 4 S 4	M 4 S 3+ M 4 S 4			−
P 38	Jan '43	−	−	−	Ulnar Median	M 0 S 0 M 0 S 0	M 0 S 0 M 0 S 0	M 0 S 0 M 0 S 0	M 0 S 0 M 0 S 0	M 1 S 0 M 1 S 0	M 1 S 0 M 1 S 0	4 years M 1 S 0 M 1 S 0	−
P 59	Sept 43	−	−	+	Ulnar Median	M 0 S 1 M 0 S 1	M 0 S 1 M 1 S 1+	M 1 S 2 M 1 S 2	M 1 S 2+ M 2 S 2+	M 2 S 3 M 2 S 3	M 2− S 3 M 4 S 3	4 years M 2+ S 3 M 4 S 3	−
P 47	Jan '43	−	−	+	Ulnar Median		M 0 S 0 M 0 S 0	M 1 S 0 M 0 S 0	M 1+ S 1 M 1 S 1	M 2 S 2+ M 1 S 2+	M 2− S 2+ M 1 S 2−	4 years M 2− S 3 M 1 S 3	−
S 143	June 44	+	+	−	Ulnar Median	M 2 S 3 M 0 S 3	M 2 S 3 M 1 S 3	M 2+ S 3 M 1+ S 3	M 2+ S 3+ M 1+ S 3	M 3 S 3+ M 1− S 3	M 1 S 3 M 1− S 3	4 years M 1 S 3− M 1− S 3	−
S 158	Feb 45	−	−	+	Ulnar Median	M 2 S 4 M 2 S 4	M 2+ S 4 M 4 S 4	M 1+ S 4 M 5 S 4	M 5 S 4 M 5 S 4				−
S 104	Aug 43	−	−	+	Ulnar Median		M 1 S 1 M 1 S 1	M 1+ S 1+ M 1+ S 1	M 1+ S 1+ M 1+ S 4	M 1+ S 2 M 1+ S 1	M 1+ S 2 M 1 S 4	4 years M 1 S 3 M 1 S 4	−
W 102	June '44	+	−	+	Ulnar Median	M 0 S 0 M 0 S 0	M 0 S 0 M 2 S 1	M 1 S 0 M 2 S 2+	M 1 S 2 M 2 S 3	M 1 S 3 M 2 S 3	M 1 S 3 M 2 S 3	4 years M 1+ S 3 M 2 S 3	−

ANALYSIS OF THE RESULTS OF OPERATIVE EXPLORATION OF T CHIAL PLEXUS IN TWENTY-TWO CASES

Case No	Delay before operation	Scar	Nerves exposed	State of nerves	Prognosis on operative findings	Repair affected	Recovery at 2 years		
							Group I	Group II	Group III
B 171	Months 2	±	C 5, 6 7 and posterior cord	C 7 Lesion involving about one-third of root			A 4+ E 5 F 4		Median M_3 S_3 Ulnar M_2 S_4
B 195	5	++	All trunks	Outer trunk—thinned to two-thirds diameter Other trunks — ' typical colouration of degeneration	Good		A 4+ E 2 F 4+	P 1	Median M_2 S_2 Ulnar M_1 S_2
B 113	11	+	C 5 6	Soft scar tissue No obvious lesion in part exposed			A 2 E 2 F 2		
F 47	5	++	Posterior cord Lateral cord Median nerve	Very extensive scarring which did not permit full exposure				P 5	Median M_4 S_{3+} Ulnar M_4 S_3
F 15	5	++	Lateral cord Medial cord Posterior cord Musculocutaneous nerve Ulnar nerve	Lateral cord—enveloped in scar Posterior *and medial cords*—felt and looked normal Ulnar nerve—looked degenerate	Good				Median M_1 S_0 Ulnar M_1 S_0
H 95'	6	±	Upper trunk C 5 6, 7	Upper trunk—at junction of C 5 and 6—firm neuroma involving two-thirds of C 5			A 4 E 2+ F 4+		
H 113	4	±	C 5 6 7	C 5, 6 Two lateral neuromata—generalised intraneural scar C 7 Firm fusiform neuroma intraneural scar			A 3 E 3 F 4	P 0	Median M_1 S_2 Ulnar M_1 S_2
H 2	8	±	Lateral cord Medial cord Posterior cord	Posterior cord—encased in scar felt indurated—branches appeared normal Inner cord—branches wasted cord not seen because of scar				P 4	Median $M_{1+}S_4$ Ulnar M_1 S_1
H 115	3	±	C 5 6 7	Slight epineural scarring at origin of C 5 6	Good		A 4 E 3 F 4		
K 7	4	+++	Lateral cord Medial cord Posterior cord	Lateral cord—surrounded by scar Medial cord—normal Posterior cord—involved in dense scar			A 4+ E 4 F 5	P 4	Median M_3 S_3 Ulnar $M_{4+}S_4$
				No lesion seen as far as	Good		A 4 E 2		

K 8	13	++	Lateral cord Medial cord Posterior cord	Suprascapular nerve Lateral pectoral nerve	Suprascapular nerve—lateral neuroma Median head of median nerve—divided Lateral cord—divided Posterior cord—no obvious lesion	Gap in median nerve 15 cm		A 2 E 0 Γ 0	P 1	Median M_0 S_0 Ulnar M_5 S_4
L 65	5	++	Lateral cord Posterior cord	Circumflex nerve	Lateral cord—enveloping scar Posterior cord—fusiform neuroma					
Mc 26	11	+	Medial cord Posterior cord		Neuroma on medial part of medial cord				P 4	Median M_3 S_{3+} Ulnar M_4 S_4
M 101	5	±	Lateral cord Medial cord Posterior cord		Posterior cord—small firm neuroma Lateral cord—surrounded by dense scar Medial cord—normal	Good			P 3	Median $M_{1+}S_1$ Ulnar M_0 S_0
P 59	4	++	Lateral cord Posterior cord	Median nerve	Posterior cord—soft neuroma Lateral cord—soft fusiform neuroma Lateral root of median—soft fusiform neuroma			A 4 E 4 Γ 5	P 1	Median M_2 S_{2+} Ulnar $M_{2+}S_2$
P 47	6	±	Lateral cord Medial cord	Ulnar nerve	Lateral cord—small neuroma Medial root of median—divided Medial cord—small neuroma Ulnar nerve—flattened	Good		A 0 E 5 Γ 4	P 3	Median M_2 S_3 Ulnar M_2 S_3
S 158	2	±	Upper trunk		Division of branches of upper trunk		Suture of medial and lateral roots of median nerve		P 4	Median M_1 S_{2+} Ulnar M_2 S_{2+}
S 104	9	–	Medial cord Posterior cord		Thickening of sheath of medial and posterior cords Below this medial cord typically degenerate		Grafts to divisions of upper trunk	A 2– E 0 Γ 0	P 5	Median M_3 S_4 Ulnar M_3 S_4
V 7	4	±	Medial cord and branches		Inner cord—adhesions at divisions Ulnar nerve looked degenerate	Axonotmesis Perfect recovery should occur			P 4	Median $M_{1+}S_1$ Ulnar $M_{1+}S_2$
V 11	1	++	C 5, 6		C 5 6—swollen firm thickened sheath Incision of C 5 showed much fibrous tissue but two normal bundles seen			A 4+ Γ 4+ Γ 4–		Median M_1 S_0 Ulnar M_2 S_0
W 102	4	++	C 5, 6 7 Upper trunk	Suprascapular nerve	Upper trunk—divided C 7 branch intact joining distal		Suture of upper trunk	A 2 E 0 Γ [illegible]	P 3	Median M_2 S_3

than two years many patients adopted a one-armed way of life so that, even with good proximal recovery in the injured limb, little use was made of it Close questioning of the twenty-five patients in this group revealed that eighteen did not use the limb at all for finer work such as writing, using a knife and fork, doing up buttons, or opening doors, and one patient summarised his use of the limb as "an emergency paper-weight" Of the other seven cases, four found that the limb was useful in everyday life, and three were equivocal

Paralysis with injury to a main vessel—In eleven cases, a main artery or vein was found to be damaged either at the time of primary wound excision or at subsequent exploration The vessels involved were subclavian artery, 1, axillary artery, 5, brachial artery, 1, subclavian vein, 2, axillary vein, 2 In four, the arterial lesion was revealed by the appearance of an aneurism some time after the original wound had healed In three, the artery was ligated at the time of primary wound excision With one exception, venous damage was noted at the time of wounding In one, ligation of the third part of the axillary vein and artery was performed at the primary operation

The most striking complication which was common to all these cases was joint stiffness, particularly in the hand In only one case was there evidence of ischaemic damage to muscle or nerve (F 15, Table IV) At the time of primary wound excision the axillary artery and vein were seen and found to be undamaged, the radial pulse was normal Twenty-four hours later, arterial spasm developed with disappearance of the radial pulse Injection of novocain into the stellate ganglion gave rise to some improvement in the peripheral circulation but was soon followed by gangrene of the terminal phalanges of the index, middle, and fifth fingers The plexus was explored five months after injury and no lesion was found, apart from scarring round the nerves Recovery was poor, and five years after injury the fourth and fifth digits were amputated through the metacarpo-phalangeal joints At operation the digital vessels were found to be patent and of normal appearance, but the nerves were thin and translucent

Horner's syndrome—Five cases showed a typical Horner's syndrome either immediately after injury or some weeks later Two, which were associated with an aneurism, did not develop the syndrome until some time after injury and in neither case did treatment of the aneurism cause disappearance of the well-known signs The third and fourth cases were of interest In both, the damage involved mainly the upper trunk and there was little disturbance of the rest of the plexus One was due to a close range blow-back from a field gun, Horner's syndrome persisted for some weeks, but when examined six months later it had disappeared and tests showed almost normal sweating throughout the limb and face In the other, even three months after injury, there was complete anhydrosis of the left upper limb and half the face, but with little sensory disturbance In the fifth case, it was found at operation that there was fracture of the first and second ribs with perforation of the dome of the pleura and lung The neurological findings were those of a complete lesion of the entire plexus

The two examples of Horner's syndrome with aneurism were notable in so far as sweating loss was by no means complete in the upper limb, and although pressure effects of the aneurism were removed the signs did not disappear, thus not conforming to the peculiar regenerative properties often attributed to the sympathetic nervous system In the next two cases it is difficult to imagine how a missile which must have passed very wide of the stellate ganglion could have produced such a syndrome, except by the concussive effect demonstrated experimentally in high velocity missile wounds by Davis *et al* (1947) Such explanation is supported by rapid disappearance of the syndrome in one of them In the final case, it seems probable that fractures of the first and second ribs caused secondary injury of the stellate ganglion Clinical observations in these patients suggest that the appearance of Horner's syndrome after novocaine block of the stellate ganglion does not necessarily prove that all sympathetic fibres to the limb have been physiologically interrupted

SUMMARY

1 In the first 1600 of the series of peripheral nerve injuries treated during the years 1940–45 at the Peripheral Nerve Injuries Unit, Oxford, 52 per cent were due to penetrating wounds, and 6 per cent of these involved the brachial plexus

2 A specific method of grouping and grading recovery is described Group I—lesions of the roots and trunk of C 5, 6, Group II—lesions of the posterior cord, Group III—lesions of C 8, T 1, and the medial cord

3 The recovery of cases in Group I was good, in Group II fair, and in Group III poor

4 The brachial plexus was explored on twenty-two occasions Only in four instances was there interruption of continuity—which is in striking contrast with the frequency in more distal degenerative nerve lesions in open wounds

5 There is no evidence to suggest that neurolysis influenced motor or sensory recovery, but on one occasion it relieved persistent pain in the limb In general the correlation between operative findings and prognosis was not precise

6 With one exception, no recovery of consequence took place in the small muscles of the hand after a lesion in continuity, although galvanic stimulation to all paralysed muscles had been given regularly

7 There is evidence to suggest that innervation of the biceps may not always be limited to C 5 and 6 and that in a proportion of cases C 7 may make a substantial contribution

8 In five cases (12 per cent) Horner's syndrome was present, the causation is discussed

9 In every case of damage to a main vessel there was a marked tendency to joint stiffness, particularly in the hand, but on one occasion only was there evidence of ischaemic changes in the muscles and nerves

10 The good spontaneous recovery which occurred in Groups I and II, the poor recovery in Group III even in cases where there was an apparently favourable lesion in continuity, the rarity with which division of nerves was found at operation, and the discouraging results of repair in three cases, make it necessary to conclude that routine exploration of open wounds of the brachial plexus is neither profitable nor justifiable

I am most grateful to Mr H J Seddon for constant encouragement and invaluable advice

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AN OPERATIVE APPROACH TO SUPRACLAVICULAR PLEXUS INJURIES

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Injuries to the brachial plexus above the clavicle are not infrequent either in civilian or military practice They are serious problems because of the site and extent of damage, and the residual disability which may remain The slow process of regeneration after nerve injury at this high level makes preservation of the muscle end-plate mechanism difficult, it favours muscle atrophy and digital contractures Such harmful sequelae of denervation can be greatly limited by adequate pysiotherapy and electrotherapy, but if one is to embark on the long programme of conscientious treatment that is essential for useful recovery, the possibilities of axon regeneration should be established early If this cannot be settled by clinical and electromyographic studies it is better to explore early, rather than wait eighteen or twenty-four months for clinical verification of complete neurotmesis There has been more reluctance to explore these injuries than in the case of nerve injuries in the extremities, the deterrents have been the possibility of damage to adjacent vital structures, and also the possibility of vascular and other complications In exploring twenty-one, of one hundred and five of these injuries, the author has used a slightly different approach which has proved helpful

OPERATIVE APPROACH

The classical supine position on the operating table has been altered to a sitting posture (Fig 1) With the head rotated away from the injured side, the point of the shoulder drops and remains dependent in this position, thus increasing the length of nerve trunks which can be explored above the clavicle The operating field is lifted so that it is directly in front of the surgeon, and it remains comfortably accessible during the long and sometimes tedious dissection An almost vertical incision is used, extending from the mid-point of the lateral border of the sternomastoid to the middle third of the clavicle It may terminate at the inner third to reach the lower roots, or veer towards the outer third when exploration of fifth and sixth roots is most important The external jugular vein is ligated and the sterno-mastoid muscle retracted The omohyoid is exposed and divided The suprascapular and transverse cervical vessels are ligated The brachial plexus is then obvious, streaming out between the scalenes The dependent position of the shoulder places the structures of the posterior triangle on a gentle stretch, facilitating dissection and identification in layers Through the vertical incision, access to the front and back of the roots is afforded (Fig 2) Once the upper root is identified, the structures may be "wiped" forwards and medially, allowing dissection from the posterior aspect This is often helpful, because scar tissue may not have penetrated to this layer and the roots may thus be identified more easily

After identification of the upper roots and trunks, from the side as it were, dissection is continued along the anterior and posterior aspects, tracing the roots distally into the interval between the two scalenes (Fig 3) The scalenus anterior may then be retracted medially and the other roots identified in serial fashion Once the correct plane of the trunks has been obtained, dissection towards the medial side is greatly facilitated even in densely scarred areas The plexus may be followed distally, and freed well under the clavicle The dependent position of the shoulder tends to pull the clavicle out of the way and it allows the trunks to be explored well beneath the clavicle At the same time, the trunks remain closer to the surface instead of dropping posteriorly as is the case when the horizontal position is used, in which position, incidentally, a sand bag behind the scapula tends to push the whole girdle forwards and obstruct the base of the posterior triangle

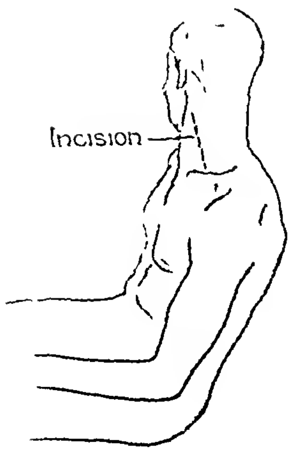

FIG 1

A semi-sitting posture is used, allowing the shoulder to drop

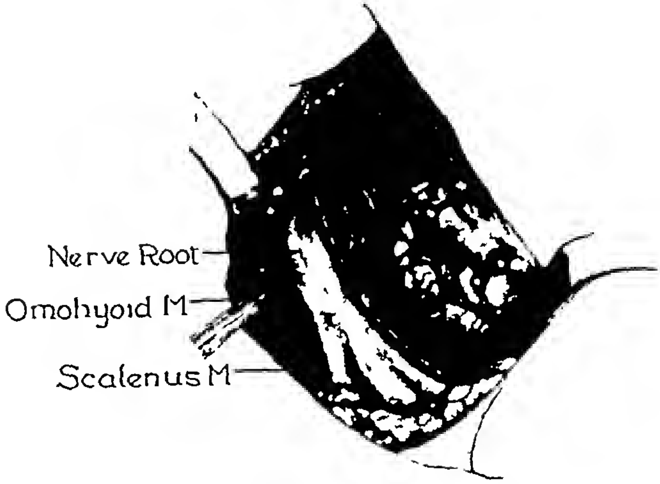

FIG 2

Dissection for exposure of the roots begins from the lateral side in the region of the dotted line lateral to the upper trunks

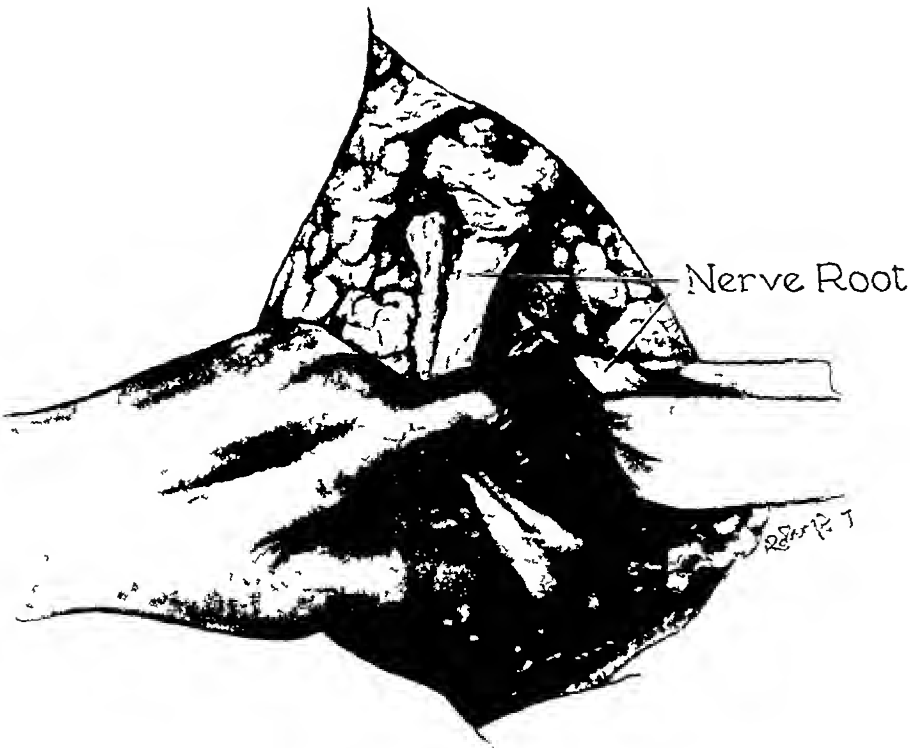

FIG 3

The trunks are dissected from anterior and posterior aspects and exposed from above downwards

When further exposure is necessary, the incision described is extended in a "Z" fashion with the transverse part along the middle third of the clavicle and the distal part extending from the lateral third of the clavicle The clavicle is divided just lateral to the mid-point and retracted by steel wires placed through drill-holes which are inserted before the bone is divided These wires serve as retractors and as a quick method of fixation and closure

TABLE I

SUPRACLAVICULAR PLEXUS INJURIES

Operations

	No	Upper trunk	Middle trunk	Lower trunk	Recoveries Complete	Partial
G S W	8	2	2	4	0	8
Traction lesions	13	8	2	3	5	8
Total	21	10	4	7	5	16
Percentage		48%	19%	33%	24%	76%

Number of injuries	105
Number of operations	21

Incidence of involvement of the various trunks and the results are shown

SUMMARY

The use of the upright position of the patient, and a vertical incision for exposure of the brachial plexus, has been attended by no complications or serious hazards The aid of skilled anaesthetists is acknowledged The structures are visible and accessible, the operative field is steady, bleeding is controlled easily, and dissection is facilitated By this technique it has been possible to explore a larger field from above, and division of the clavicle has seldom been necessary Finally, and of importance, the operative area at shoulder level enables the surgeon to continue tedious dissection for some hours comfortably, and to escape post-operative postural complications in his own back

CERVICAL PLEXUS INJURIES

As an Extension of Brachial Plexus Injuries

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The purpose of this communication is to describe a little-known complication of traction injuries of the brachial plexus Seven cases of traction lesions of the brachial plexus were admitted to a Peripheral Nerve Injury Centre in 1940 and 1941 Two of these, on careful sensory testing, revealed that there was complete anaesthesia of the area supplied by cutaneous branches of the ipsilateral cervical plexus

Case 1 C T, aged 26 years—Admitted November 29, 1940—*History*—On October 5, 1940, the patient was knocked off a cycle by a motor-car He could not remember any details of the accident and had no information regarding the manner in which he struck the ground He remained unconscious for twelve hours from the time of injury The only wounds were abrasions of the face There were fractures of the

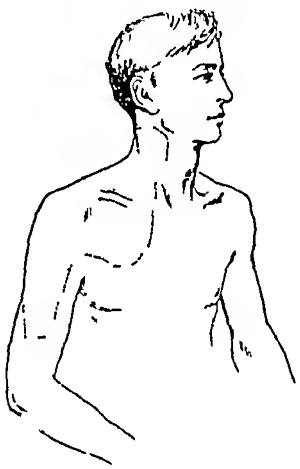

Fig 1

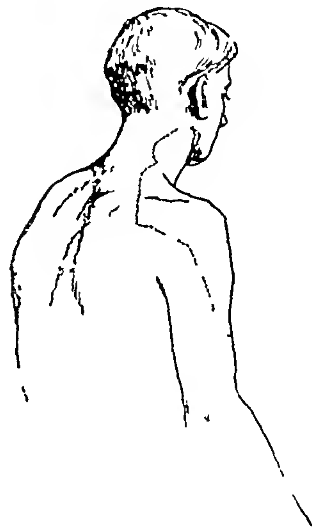

Fig 2

Case 1 Area of sensory loss (light touch and pin-prick) which corresponded exactly with the area of anhidrosis disclosed by the sweat test (Guttman technique)

three inner metacarpals and of the clavicle at its outer third The fractured clavicle was treated by bandaging the shoulder back, the hand being placed in plaster-of-Paris A brachial plexus lesion was diagnosed early in November and the arm was placed in an abduction plaster on November 17, 1940 When admitted to the Nerve Injury Centre the subjective complaints were of an area of numbness above the shoulder and inability to abduct the arm at the shoulder

On examination—Right upper limb—wasting of deltoid spinati and to a very slight extent of other muscles of the arm Nutrition of limb normal Skin a little drier than the opposite side *Sensory examination*—Loss to light touch and almost equally extensive analgesia over an area extending from the angle of the jaw and the mastoid process, down the side of the neck and upper arm, to below the level of the deltoid and including the upper part of the thorax (Figs 1 and 2) No loss of vibration or joint sense The area of anhydrosis corresponded exactly with the sensory loss *Motor examination*—Complete paralysis of the deltoid and spinati, all other muscles retained full power No Horner s syndrome A diagnosis of traction injury of the upper cord of the brachial plexus was made the loss of sensibility in the cervical area was noted as a peculiarity, since it had not been observed by us before The patient was placed in an abduction plaster

Subsequent progress—January 25 1941 slight shrinkage of the area of sensory loss posteriorly February 15 1941 light stroking in the supraclavicular fossa caused a sensation of tingling in the neck A week later a few fibres of deltoid showed a flicker of contraction but on March 25, 1941 this had disappeared again On the same date two small areas of skin above the clavicle had recovered appreciation of pin-prick and sweating reappeared in this region May 23 1941 evidence of some recovery of power in the spinati

June 13, 1941, deltoid recovering, diaphragm observed by radioscopy and found to be paralysed on the right side June 27, 1941, no objective sensory loss in the cervical region but the patient stated that he experienced a peculiar tingling sensation when shaving this side of the neck and that there was a qualitative difference in appreciation of both light touch and pin-prick, pain sensibility still lost over the deltoid muscle October 1941 deltoid and spinati contracting strongly, though still weaker than normal, area of sensory loss unchanged When the patient was last examined in May 1942, *the deltoid and spinati* showed normal power There was still paraesthesia in the cervical area and loss of sensibility over the deltoid

Case 2 E H, aged 23 years—Admitted April 3, 1941—*History*—On March 12, 1941, patient was involved in a motor cycle accident and had no recollection of what happened When he recovered consciousness he was numb over an area extending from the right side of face and scalp down to his fingers About one week later the arm was put in an aeroplane splint Radiography (including the cervical spine) revealed no bone injury

On examination—A diagnosis was made of plexus injury involving the second to seventh cervical nerves, paralysis of muscles supplied by fifth sixth, and seventh cervical segments and paresis of muscles supplied by second, third, and fourth cervical segments a large area of sensory loss over the lateral side of the arm, the deltoid, and the lateral side of head and neck to just behind the ear (Figs 3 and 4) No Horner s syndrome April 5, 1941, an abduction plaster applied

Subsequent progress—April 9, 1941, tingling sensation in the palm and all fingers if the position of the

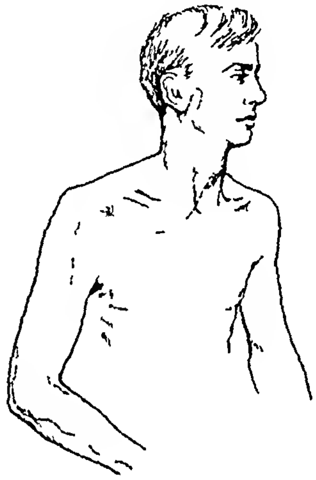

Fig 3

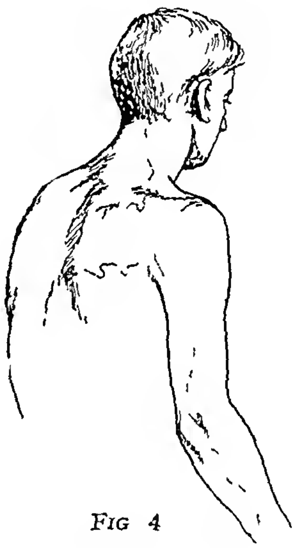

Fig 4

Case 2 Area of anaesthesia (loss of appreciation to light touch)

arm was changed At times he complained of a shooting sensation which began in the middle of the arm and radiated down to the fingers There was also pain like an electric shock which started approximately half-way down the anterior border of sterno-mastoid and radiated to the finger tips April 14 1941, patient noticed that if he moved his forearm from the plaster he was able to flex his wrist and also slightly to extend it He had some power in his fingers although he could not straighten them The hand was usually cold, but occasionally sweating occurred and appeared to be more profuse than on the other side Objectively, there was involuntary twitching of the thumb and of the muscles of the right side of neck *Complete paralysis of spinati, deltoid, pectoralis major*, biceps, brachialis, triceps, and extensors of the wrist and fingers Other muscles of the forearm and hand were weak but soon recovered almost full power May 23, 1941, no significant change, except that the extensor carpi ulnaris was contracting Screening of the diaphragm showed paralysis of the right half, which was still present as late as September 3, 1942 October 1941, the patient complained of a peculiar " tightening and quivering feeling " in the neck and side of the face when shaving or having his hair cut He felt as though he needed to draw his face away from the razor Objectively the area of sensory loss had receded but still included the whole supra-clavicular fossa although the sweat test showed that anhydrosis was present only over the arm and shoulder Motor and sensory recovery occurred gradually and he was observed at intervals until March 15, 1943 At a final examination, January 27, 1947 Mr R Roaf was unable to demonstrate any area of complete sensory loss though there was still some impairment of sensibility over the deltoid On that date the anterior fibres of the deltoid, the sternal head of pectoralis major, the triceps, and the ulnar intrinsic muscles were still paralysed The other muscles of the limb showed more or less weakness and none was normal The patient could use the arm only for holding light objects and for writing a little

Three or four other cases were observed in which the area of sensory loss extended to the supra-acromial area but they have not been included because of the known variability of distribution of the fourth and fifth cervical dermatomes and because of the inclusion of part of the fourth cervical root within the definition of the term " brachial plexus " It will be noted that the type of injury sustained by both patients described above is a common one and it is surprising that comparable cases do not appear to have been described

A number of cases of the Kofferath syndrome have been recorded (Gournay 1936, Sobolevitsch 1936, Granet 1937, Melamed 1938), in which birth injury to the brachial plexus was associated with paralysis of the diaphragm—but no assessment of the area of sensory loss was possible In the German literature (Curschmann 1928, Schnek 1928) the use of the term " cervical plexus " appears to be synonymous with " brachial plexus "

Anatomically one would expect that forcible separation of the head and neck from the shoulder would be attended by stretching of all nerves running obliquely downwards from the cervical spine and that the cervical plexus would suffer before the upper cord of the brachial plexus Yet I have never seen supraclavicular anaesthesia in several hundred patients with head injuries

Local contusion of the sensory nerves, as they emerge from the deep cervical fascia along the posterior border of the sterno-mastoid muscle, might be advanced as a possible explanation, but there was no record of bruising of the neck in either of the two cases There can be little doubt that they are examples of traction injury of the cervical plexus in association with a traction lesion of the brachial plexus

It is significant that both patients recovered sensibility in the affected area, after passing through a stage of abnormal sensation, and that recovery also occurred in both sensory and motor fibres of the brachial plexus The occurrence of sensory loss in the upper cervical dermatomes cannot, therefore, be regarded as a sign of overwhelming damage to the brachial plexus

SUMMARY

Two cases are described in which a traction lesion of the brachial plexus was complicated by sensory loss and anhidrosis in the second, third, and fourth cervical dermatomes Both patients recovered spontaneously, though in one the recovery of muscle power in the limb was incomplete It is believed that both were examples of a traction lesion of the cervical plexus No similar case appears to have been recorded

Both patients were treated in collaboration with Messrs R Barnes, J Doupe and C H Cullen, and I am indebted to Mr R Roaf for ' follow-up " notes on one of them Professor G Jefferson encouraged me to believe that the observations were worthy of record and I first reported them to the Society of British Neurological Surgeons in July 1941

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LATE SPINAL PARALYSIS AFTER AVULSION OF THE BRACHIAL PLEXUS

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Scars of the brain and of peripheral nerves are familiar conditions in medical practice, but involvement of the spinal cord in a scar, without initial cord injury, is unusual. In the case to be described there was avulsion of the brachial plexus on one side without apparent cord injury. Many years later it was found that the scar, in which cervical nerve roots were involved, had exerted an extraordinary influence upon the spinal cord. It is believed that the complication which occurred in this case may well be of unsuspected importance in other examples of brachial plexus injury.

A man, aged sixty years, who had lost his right arm in childhood at the level of the shoulder joint, was admitted to the Royal Victoria Hospital, Montreal, in 1931. During the preceding nine years he had suffered increasing weakness of both lower limbs until he walked only with the greatest difficulty.

His story was that, at the age of fourteen years, he was spending his summer holidays working in a mill, a common custom among the thrifty families of Nova Scotia. By accident his upper limb was caught in a high-speed belt and was completely avulsed from the shoulder. He recovered, and there was no record of paralysis of any other part of the body at that time. He finished school, graduated from his University, and in due time was admitted to the Bar. He practised law actively until the age of fifty-one years. During the next nine years there was increasing weakness of the lower limbs, necessitating admission to hospital.

Examination showed weakness and spasticity of both lower extremities, more marked on the right. There was complete loss of pain and temperature sensation on the left side of the body up to the second thoracic segment, and incomplete loss of sensation on the right side up to about the same area. He had enophthalmos and ptosis (Horner's syndrome) due to sympathetic involvement on the right side, the side on which the upper limb was missing, and there was absence of sweating of the face on that side. Lumbar puncture showed that there was no block to the passage of spinal fluid.

Operation was decided upon and lower cervical laminectomy was carried out. It was found that the dura pulsated freely, but when it was opened the operator was shocked to find no spinal cord at all! Further examination showed that at the level of the first thoracic segment the whole spinal cord was displaced across to the right, beyond the midline (Fig. 1). It actually passed in a curve out into the intervertebral foramen and back again. The foramen was enlarged in such a way as to form a funnel-shaped cavity. At the apex of this funnel the dura passed out along what must have been the first thoracic nerve. It seemed quite evident that the whole cord had been drawn gradually into this funnel-shaped cavity and that the cavity had been enlarged by contraction of the cicatrix.

The cicatrix could act upon the cord only through the sheath of the former right first thoracic nerve. The roots of the left first thoracic nerve were stretched to twice their usual length. The cord itself was not much atrophied. Bone was removed widely on the right side at the site of the traction upon the cord until the sheath of the right first thoracic nerve was well exposed. This was cut across and it was then found that the spinal cord came back across the spinal canal to the midline.

After operation there was some increase in the weakness but improvement began at about the third week and continued for several months. He returned home after an extended convalescence, and at the end of five years his uncle wrote that he had been getting about "as well as ever," although suffering from very high blood pressure. He died of cardiac

disease at the age of sixty-five years, without our seeing him again It was then reported that in the few months before his death, weakness in the legs had returned and progressed, but whether from systemic or local causes is not certain

It is suggested that at the time of avulsion of this boy's arm, the first thoracic nerve was drawn out and severed within the spinal foramen, thus exerting traction upon, but causing

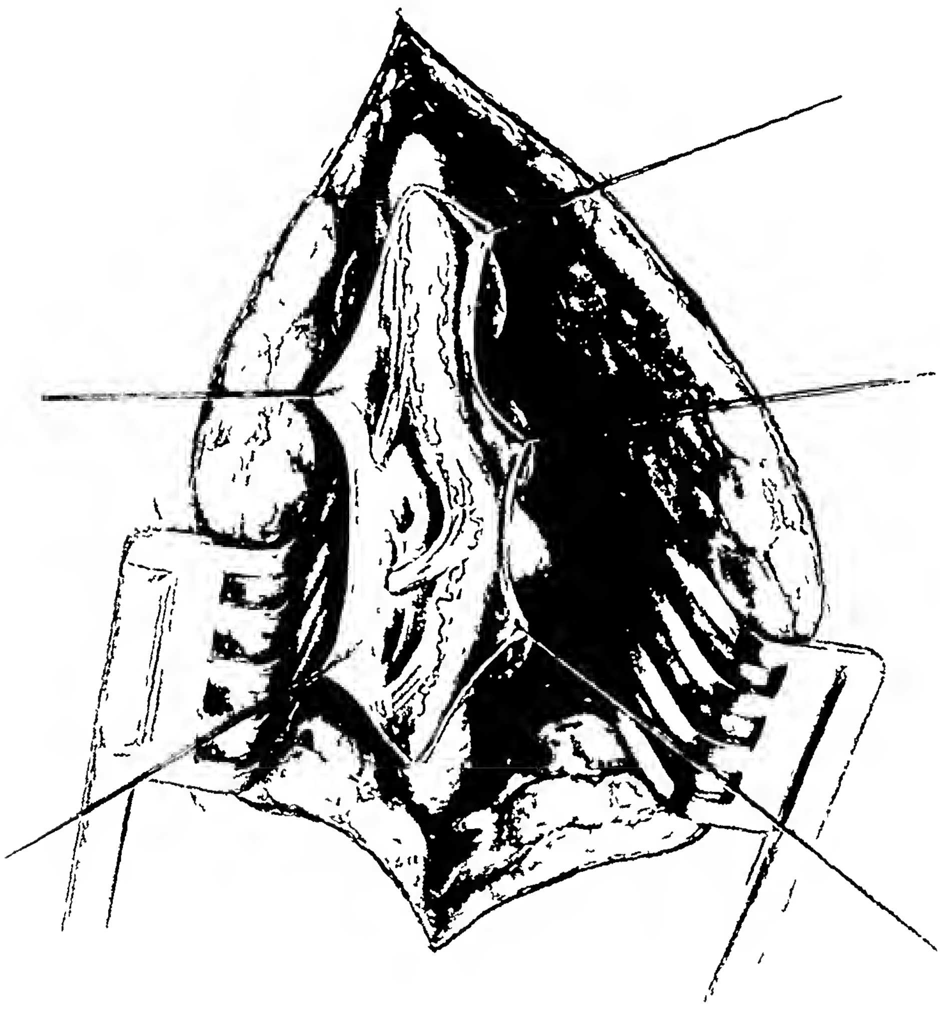

FIG 1

Cicatricial contraction at the level of the first thoracic root pulling the cord into the foramen of the nerve and causing spinal paralysis forty-six years after the injury which caused avulsion of the brachial plexus

no injury to, the cord The scar which formed in the remaining segment of the nerve and meninges eventually contracted to such an extent that it literally pulled the cord into the foramen of the nerve and finally produced compression of the spinal cord or interference with its circulation Strange to say, it was not until thirty-seven years later that spinal symptoms first developed, and it was not until forty-six years after injury that the symptoms became incapacitating

THE TREATMENT OF RESIDUAL PARALYSIS AFTER BRACHIAL PLEXUS INJURIES

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Problems arising in the treatment of disabilities remaining after brachial plexus injury, with residual paralysis of varying location and degree, and sometimes with aggravation by the contractures of muscle fibrosis and the effects of indifferent splintage, are almost as numerous as the cases themselves Far too often, amputation has been accepted as the only solution Experience which has been gained during the past eighteen years in the treatment not only of paralysis due to brachial plexus injuries, but also of paralysis due to poliomyelitis, and muscle injuries due to soft tissue wounds of the forearm, has shown that even in a limb which is apparently useless it may be possible to restore a degree of function which is much to be preferred to that of an artificial limb Amputation should not be considered, even at the request of the patient, without some preliminary effort at improvement Furthermore, it should not be accepted that there has been complete failure of recovery, and it should not be proposed to start reconstructive measures, until adequate treatment has been continued long after the conclusion of periods estimated theoretically on the rate of nerve regeneration The opinions which are expressed in this article, and some of the procedures which are recommended, are based not only upon this experience but on long observation of many cases treated by other surgeons Many operations which were calculated to improve function have been found to fail at an early stage, or at least to lose initial promise after varying periods

Except when the paralysis is equivalent to loss of the musculo-spiral nerve, or to a high combined lesion of the median and ulnar nerves, it is almost impossible to classify these cases In determining what best to do for any particular patient the limb must of course be viewed as a whole, but in this study the problems will be considered under regional headings the hand, the wrist, the forearm, the elbow, and the shoulder

THE HAND

Musculo-spiral paralysis—When residual loss of function is almost equivalent to that of musculo-spiral nerve paralysis, transplantation of the wrist flexors in order to activate the thumb and finger extensors is so effective, and has been discussed so fully by Zachary (1946), that only two comments will be made from a personal experience of fifty-five cases—thirty-two of which involved the musculo-spiral nerve, nineteen the posterior interosseous nerve, and four the extensor muscles themselves In the first place it is wise to transplant the flexor carpi ulnaris to the extensor indicis and extensor pollicis longus as well as to the extensor communis digitorum Secondly, when palmaris longus is absent, or when all flexors of the wrist have been utilised for transplantation, arthrodesis of the wrist joint should be deferred until it is certain that the expected gain in extensor power of the fingers will offer greater practical advantage than mobility of the wrist joint

High combined median and ulnar nerve lesions—When the median and ulnar nerves are affected in the forearm, separately or together, the residual effect is no more than part of that of a high combined lesion, so that only the latter will be discussed, the problem of the fingers being considered separately from that of the thumb

Fingers—Transplantation of one wrist extensor or supinator longus (brachio-radialis) to flexor profundus digitorum, as recommended by Stiles and Forrester-Brown (1922), is

effective in restoring flexion to the fingers The author has performed this operation in eleven cases, using supinator longus in two, and extensor carpi radialis longus in eight The other case was one of poliomyelitis with normal wrist flexors and extensors, and transplantation was carried out by inserting the extensor carpi radialis longus and extensor carpi ulnaris into flexor profundus digitorum, and at a later stage, flexor carpi ulnaris into extensor communis digitorum and extensor indicis This gave excellent improvement in the power of grasp and the strength of extension movement at the metacarpo-phalangeal joints Power to flex the fingers is thus assured, but there still remains the difficult problem of loss of active extension of the interphalangeal joints when these, and the metacarpo-phalangeal joints, are mobile

It has long been observed that if extension of the proximal phalanges is restrained at the metacarpo-phalangeal joints, the common extensor muscle extends the interphalangeal joints This is but a further example of the principle concerned at the wrist joint after transplantation of all flexors to the thumb and finger extensors, namely, that complementary action is necessary in order to restrain the more proximal segment and allow the more distal segment to be moved In the hope that such restraint might be provided at the metacarpo-phalangeal joints, even if it did not actively extend the interphalangeal joints, the sublimis tendons were transplanted on three occasions to the lumbricales in the manner advocated by Bunnell (1942), the supinator longus or a radial extensor being transplanted into the sublimis tendons above the wrist The supinator longus was selected in two cases where the extensor carpi radialis longus had been inserted into flexor profundus digitorum, because it was considered that re-education of one wrist extensor to extend the interphalangeal joints, while the other wrist extensor flexed them, would be difficult or even impossible In a third case, the use of activating muscles was reversed All three failed

That arthrodesis, or even fibrous ankylosis of the metacarpo-phalangeal joints, would serve well, provided only that it was achieved without interference with free mobility of the extensor cuff, was well proved in one patient who had a combined lesion of the median and ulnar nerves in the upper arm, with a 10 centimetre gap in each The fingers, and especially the metacarpo-phalangeal joints, were very stiff These were brought gradually to a degree of flexion just short of the right angle, and held there while the interphalangeal joints were mobilised At a later date, extensor carpi radialis longus was inserted into flexor profundus digitorum Excellent function was gained and it has been maintained Nevertheless, with the exception of one case mentioned later, arthrodesis of the metacarpo-phalangeal joints has not been done in this type of case Good functional results demand free play of the extensor cuff, the movement of which would almost certainly be restricted by operative exposures, especially in the middle and ring fingers If this happened, or if in attempting to avoid it arthrodesis failed by reason of cautious and inadequate dissection, the alternative of interphalangeal arthrodesis would then be impracticable, the success of interphalangeal arthrodesis depends essentially on free mobility of the metacarpo-phalangeal joints

In patients with mobile finger joints, the procedure which finally has been adopted is arthrodesis of the proximal interphalangeal joints, just above the right-angle in the case of the middle, ring and little fingers, and at a rather wider angle in the index finger so that the tip of the digit can meet the thumb for a pincer effect This operation has been done in seven cases of paralysis, and one of crushing injury to the fingers In one patient, after supinator longus had been transplanted into flexor profundus digitorum (and after an attempt to activate the lumbricales, as described above, had failed) the metacarpo-phalangeal joint of the index finger, and the interphalangeal joints of the other fingers, were arthrodesed full extension of the index was not obtained, probably for the reasons indicated

In only one finger has later arthrodesis of a distal joint been necessary for flexion contracture Fixation of the extensor tendon at the proximal joint tends to prevent deformity

If the finger joints are not freely mobile, arthrodesis should be deferred until it has been noted whether or not, after tendon transplantation and functional activity, there has been gain in the range of movement of one or other group of joints The joints with the more limited range may then be held in the optimal position, while further movement is encouraged in the more movable joints Though movement in the individual joints of stiff fingers may be little, the total may justify tendon transplantation, giving a useful increase in the range

Thumb—The fact that so many operations have been devised with the object of securing opposition of the thumb is, in itself, an indication that most of these procedures are liable to fail sooner or later Even when the opponens alone is paralysed, the experience of this writer, over many years, has shown that no tendon transplantation is consistently successful in restoring opposition and at the same time leaving full mobility of the thumb Several factors are responsible for this failure Opposition of the thumb is an admirably co-ordinated combination of abduction and flexion movements at the carpo-metacarpal joint, during which the opponens moves with the metacarpal through an arc, rather like that of a stay-wire moving with the jib of a crane This effect is never reproduced fully by any tendon transplantation and it seems that the operations fail because there is inability to maintain the abduction quotient Some early successes depend on abduction being impressed on the metacarpal by pressure against the capsular ligaments, and by close approximation of the carpo-metacarpal joint surfaces Sooner or later, however, the obliquity of this pressure stretches the capsule, the joint surfaces become less closely applied, abduction movement lessens, and there is increasing adduction of the thumb metacarpal towards the index finger This is particularly true of transplants which depend on the construction of a pulley near the pisiform when the thumb ultimately comes to move just across the palm But it is true lso of direct transplantation of palmaris longus, flexor carpi ulnaris, or an extensor of the umb, whether through extensor brevis pollicis or by means of free tendon graft

Other sources of failure depend on the point of attachment of the transplant to the thumb If the attachment is to the base of the proximal phalanx, whether by the short extensor or by a free graft, flexion deformity at the metacarpo-phalangeal joint always develops and increases Naturally, this lessens the range of excursion of the thumb until it may not be possible to extend it sufficiently to clear the flexing index finger When the insertion is into the metacarpal neck, the combined effect of pull of the adductor on the proximal phalanx, and lateral pressure of the thumb against the fingers, is to stretch the lateral ligament of the metacarpo-phalangeal joint, the phalanges adduct towards the index finger with corresponding loss of abduction of the thumb as a whole Such observations in lesser degrees of paralysis of the thumb, and the fact that in the severe cases now under discussion the muscles commonly used are not available, make it clear that some more radical procedure must be adopted

A feature which may often be noted in these cases is flexion deformity at the inter-phalangeal joint of the thumb despite a normal extensor pollicis longus This is due to loss of complementary action of the flexor brevis pollicis whereby the proximal phalanx is not so fixed as to allow the distal phalanx to be extended on it Such deformity must necessarily be aggravated by transplantations to activate the long flexors (Luckey and McPherson 1947)

For these reasons, the procedures adopted in cases of severe paralysis, which so far seem to have worked well, have been 1) to arthrodese the interphalangeal joint in a position just short of full extension, 2) to arthrodese the metacarpo-phalangeal joint with the phalanx sufficiently abducted on the metacarpal to compensate fixed adduction towards the second metacarpal, and rotated to such a degree that in the flexed position the thumb opposes the fingers, and 3) when these two joints are stabilised, to transplant an available wrist extensor, or supinator longus, into the long flexor of the thumb This combination of procedures has been done in seven cases, using the supinator longus in two, the extensor carpi radialis longus in two, and extensor carpi ulnaris in three In two cases where the

thumb was markedly adducted by contracture, it was freed at a preliminary operation by filleting the tissues in the first interosseous space

Cases with some recovery of the flexors alone—Apart from the two groups already considered, one of the most common findings in brachial plexus injuries with limited motor recovery is that of moderate power in the flexors of the wrist and fingers In such cases the extensors, and the intrinsic muscles, are usually lost If the interphalangeal joints are mobile it is usually better to leave them so, it may well be that the patient will find it more useful to rely on passive opening of the fingers by which to grasp an article and hold it the more firmly (as in the case reported on page 48—T H J, 1932) If however, by reason of flexion contracture, arthrodesis cannot be avoided, the position in which the joints should be fused will vary in accordance with the range of movement at the metacarpo-phalangeal joints the less the range, the straighter should be the fingers at the interphalangeal joints in order to give a wider span between finger tips and thumb

The best utilisation of wrist flexors depends on their power, and their range of excursion, which may be restricted by fibrosis If these are sufficient, the tendons can be transplanted to the finger extensors, the flail thumb being stabilised in forward abduction by arthrodesis of the interphalangeal and metcarpo-phalangeal joints with a bone-strut between the first and second metacarpals The thumb then acts as a rigid prop against which an object can be held by the fingers On the other hand, if power is not sufficient for this purpose, one or both flexor tendons of the wrist may be inserted into the flexor pollicis longus after preliminary stabilisation of the thumb which should be planned in accordance with the range of joint movement and the degree of contracture or adduction deformity, namely 1) arthrodesis of the interphalangeal and metacarpo-phalangeal joints, the thumb remaining capable of active flexion at the carpo-metacarpal joint in order to hold objects against the fingers, or 2) arthrodesis of the interphalangeal joint with the thumb fixed in forward abduction by a bone-strut between the first and second metacarpals, the metacarpo-phalangeal joint remaining mobile In either case the thumb has to be extended passively before an object can be grasped

Three patients have been seen, after suture of the main nerves high in the axilla, with hands which were completely flail except for a single wrist flexor—in two, the flexor carpi radialis, and in one, the flexor carpi ulnaris In the first two, the radial flexor tendon was left in its normal position because it was believed that if it had been transplanted to the finger flexors, opening of the grasp would have been impossible, whereas by leaving the muscle, and converting the hand into a claw by tenodesis of the finger flexors and extensors, the grasp would be closed by gravity when the wrist was extended in supination, and opened by active flexion of the wrist by the undisturbed muscle Moreover, if the tendon had been transplanted, all the effort of lifting and carrying would have fallen on the fingers, whereas by leaving it alone there would be better weight-carrying in the palm In the third case the ulnar flexor was transplanted to the long flexor of the thumb, which was arthrodesed at the two distal joints This procedure was preferred because the unopposed ulnar wrist flexor tends to deviate the hand, unlike the more centrally placed radial flexor

The completely flail hand—By utilising the effects of gravity and tenodesis, quite useful function can often be gained even in a completely flail hand, especially if the joints are mobile After fixing the thumb in forward abduction by a strut between the first and second metacarpals, the flexor tendon of the thumb and all flexor tendons of the fingers are divided and passed dorsally through a gouge hole in the radius above the wrist The extensor tendons are passed anteriorly through the same opening, both groups being scarified, and sutured together, with the wrist in slight dorsi-flexion and the finger tips just in contact with the palm Bone which has been removed may be broken up and packed round the tendons in order to ensure firm fixation When the forearm is supinated the wrist is dorsi-flexed by the weight of the hand, together with that of any article placed in it, the finger flexor tendons are thus

tightened and the article is grasped firmly When the wrist is flexed, either passively or by gravity in pronation, the tightening extensors open the hand This procedure is useful even when it is necessary to move the forearm and wrist passively, but naturally it is best when pronation and supination are controlled actively

Only one case has been seen where the hand was flail except for a single extensor of the wrist This was due not to paralysis but to wounds, with destruction by anaerobic infection and operative treatment of all the forearm muscles except pronator radii teres and the short radial extensor of the wrist The patient was treated by the tenodesis described and although he could not pick up an article, because the hand had to be extended away from it in order to close the grasp, he could maintain grasp by active dorsi-flexion of the wrist whether the forearm was pronated or supinated When a tool was placed in the hand he could wield it with great dexterity

If pronation and supination cannot be alternated, the finger flexors alone need be slung to the radius to form a hook, but this is better done with the wrist in greater flexion so that the tension of the sling, when weight-carrying, is increased If the flexor sling should stretch, or if contracture of the interphalangeal joints should develop, arthrodesis of these joints may be required This was necessary in only one case in this series

THE WRIST JOINT

Arthrodesis of the wrist joint is sometimes helpful, but mobility is no less often of value Such mobility improves function after tenodesis, and it may reinforce the power of transplanted tendons Before the wrist joint is fused—a step which is irretrievable—it should be made quite certain that stability is of greater advantage than mobility Arthrodesis can be carried out at any time, and even in the completely flail hand it should be kept in reserve as a final procedure A wrist joint which is somewhat lax can be partly stabilised by fixation of the flexor tendons, the extensor tendons, or both flexor and extensor tendons, to the radius and ulna

When the first consideration in the treatment of a completely flail hand is its appearance, arthrodesis of the wrist joint may be advisable, together with arthrodesis of any finger joint which is so contracted as to make it difficult to put on a glove The thumb should be stabilised in abduction by an inter-metacarpal bone-strut If the mid-position of the forearm is established, and the elbow is stabilised by posterior bone-block as described below, the first interosseous space and its metacarpals provide a surface upon which to balance or support such articles as, for example, a tray which may be held in the other hand

THE FOREARM

The position of the forearm is important, especially when the hand is flail or imperfectly controlled Unless well controlled, the neutral radio-ulnar position is seldom of value—the hand tends to drop into ulnar deviation, and the palm lies in a useless plane In most patients with a flail hand, full supination is better than the mid-position it offers the most useful sling, if there has been tenodesis the function is best, and the palmar aspect of the hand is presented for carrying Nevertheless if, in consequence of contracture, the wrist is still in flexion, the fully pronated position should be chosen with the fingers formed into a claw by which objects may be carried in the hook of the fingers When appearances alone are considered the mid-position is the best Correction of the position of the forearm can be secured readily by cone rotation-osteotomy of the radius in the upper half

THE ELBOW

No matter how good the hand or shoulder may be, an upper limb which hangs in full extension at the elbow joint is seriously incapacitated Active flexion is sometimes possible

by the flexor and extensor muscles of the forearm, and by the supinator longus, but only after the joint has been flexed passively to a degree which varies in accordance with the power of these muscles It is well known that such flexion can be initiated, and the mechanical advantage of the muscles improved, by transposing their origins to a higher level of the humerus (Steindler 1939) The two defects of this operative procedure are 1) power is seldom sufficient to permit carrying even moderate weights, 2) an overacting triceps, the weight of the forearm, and more especially the effect of weight-carrying, tend gradually to extend the elbow and thus stretch and weaken the muscles which have been advanced For such reasons, this author, in 1931, placed a bone-block behind the elbow by which to provide initial flexion and permit weight-carrying in front of the body Since that time the procedure has been carried out in a number of patients with limited power of elbow flexion, and in many in whom there was no power of flexion whatever

Posterior bone-block for flexor paralysis of the elbow—The operation offers many advantages Weight can be borne in front of the body, in the hook of a tenodesed hand, on the palm of a hand with arthrodesis of the wrist, or on the forearm Furthermore, the forearm can be flexed, passively if necessary, to place the hand on a table or bench Even more important, the forearm can still be put in contact with the upper arm or chest wall, out of harm's way in a crowd, a position which is impossible after arthrodesis of the joint Indeed the operation has proved so useful that it is greatly preferred to arthrodesis except in special cases where the hand and shoulder are strongly controlled and the patient's work demands a perfectly stable, rigid, and painless joint Of all procedures carried out in these severely paralysed limbs, this operation seems to have provided the greatest advantage It has been performed on twenty-one occasions in eleven patients with residual paralysis after poliomyelitis, and in ten patients with brachial plexus injuries In nine, the limb was completely flail, in two, the long head of the triceps was also transplanted to the radius in front, and in two others the flexor origins of the forearm were advanced up the humerus It is not advised in young children because it may possibly cause disturbance of bone growth, and because the best position of the joint may not be maintained

Technique of the bone-block operation for flexor paralysis of the elbow—The position of flexion at which the block is placed depends upon several factors the function in the hand, the range of active flexion which is possible, the control of the shoulder, and the occupation which the patient may have in mind The operation is easy, but it does not suffice to do no more than fill up the olecranon fossa The joint is exposed on its posterior aspect by a curved incision, thus avoiding a mid-line wound which is liable to gape when the elbow is flexed The triceps is split and retracted The tip of the olecranon process is removed in order to give a more broad surface for contact with the block With the elbow flexed to the predetermined angle, a transverse incision is made across the trochlea by which to mark the distal limit of the block, and the elbow is fully flexed A transverse channel is cut in the trochlea, extending to its lateral walls, the central part is removed up to the olecranon fossa The fossa is denuded and its upper lateral walls elevated A cortical graft, two and a half inches long and half an inch wide, is removed from the tibia and as much as is necessary to fit the transverse channel is driven in, with the cortical surface distally Excess of bone is placed vertically, above this, into the olecranon fossa and humeral medulla The triceps is sutured, the wound closed, and the limb put up in a position of comfortable flexion

One patient, whose hand was almost normal, but whose elbow and shoulder joints were flail, had been advised to have arthrodesis of the shoulder After a bone-block operation on the elbow he found that the limb was so useful that further operative treatment was declined He preferred mobility of the shoulder to any gain in power which might be conferred by arthrodesis For five years he has worked in a warehouse, carrying heavy loads and pushing wheelbarrows One other patient with similar disability, who was treated in the same way, has also declined arthrodesis of the shoulder

On two occasions, when the long head of the triceps was the only active muscle in the limb, a bone-block operation at the elbow was combined with transplantation of the triceps to the front of the radius In each case the transplant worked well in accordance with the available muscle power In two other cases, pectoralis major was inserted into the biceps no advantage was gained, but it may well be—since good results have been secured from this transplant by other surgeons—that the failures were due to faulty technique

THE SHOULDER

Arthrodesis of the flail shoulder joint is sometimes advisable in order to transmit to the humerus the power of such muscles as are still capable of active control of the scapula Moreover, even when there is little or no such power, it is often necessary to stabilise the limb in order to prevent internal rotation and loss of forward projection of the forearm which has been gained by an elbow block

Since arthrodesis of a joint is almost irrevocable it should not be advised until it is quite clear that the advantages outweigh the disadvantages In the case of the shoulder joint many women prefer to keep mobility, despite paralysis, so that it may still be possible to raise the limb passively and thus use the hand in dressing, washing, and arranging the hair The cosmetic appearance is certainly better when the limb can swing, and the shoulder be carried squarely, which is not possible after arthrodesis Some of these considerations apply equally to men, and provided that function of the hand is good, a flail shoulder is not a serious disadvantage in many occupations Arthrodesis is not advisable, therefore, in children whose future occupation cannot be foretold For many occupations such arthrodesis is a disadvantage

If it is decided that the paralysed shoulder joint should be arthrodesed, care should be taken to avoid the wide degree of abduction which is sometimes recommended If this is more than can be accommodated easily by scapular excursion, the weight of the limb when it is adducted stretches and weakens the scapular muscles and causes aching in the cervical region Similarly there should not be too much external rotation, it is seldom necessary to provide more than clearance from the chest wall

Contrary to common practice, arthrodesis of the shoulder joint should be the last major procedure in the treatment of a paralysed upper limb The ease of performance of more distal operations, and the comfort of the patient after such operations, is very much greater if the shoulder joint is freely mobile

TWO CASE REPORTS

T H J (1932), aged thirty-two years—First seen three and a half years after sustaining complete left brachial plexus paralysis due to a motor-cycle accident The plexus had been explored soon after injury He had fair scapular control Below the shoulder there was no power whatever except for a flicker in the flexor profundus of the index finger The arm dangled at the side, it was blue and cold, and it ached so badly that he demanded amputation After ten months of intensive physiotherapy, good power was regained in the flexor muscles of the fingers and fair power in the flexor muscles of the wrist There was no recovery in any other muscle group *Operative treatment* 1) The thumb was stabilised in forward abduction by a bone-strut between the first and second metacarpals The metacarpo-phalangeal joint was arthrodesed 2) The forearm, which was fully pronated, was turned to full supination by cone rotation-osteotomy of the radius so that gravity could, to some extent, aid extension of the fingers and permit weight-carrying in the palm by the wrist flexors 3) A bone-block was placed behind the elbow with the joint at an angle of 110 degrees 4) The shoulder was arthrodesed in 40 degrees of abduction, no more abduction than this was justified by the power which was available In 1934 this patient secured a job as a bus conductor in a rural service Ten years later, in 1944, he was still doing his work satisfactorily He uses the paralysed limb to hold his ticket rack

J S (1942), aged twenty-five years—First seen five years after brachial plexus paralysis The plexus had been explored Apart from a little scapular control, slight power in the long head of triceps, and a flicker of movement in the index finger flexors, the limb dangled by the side, flail, blue, and cold, with the forearm fully pronated and the wrist and fingers contracted in flexion It ached so much that he insisted on amputation Much persuasion was necessary before he was willing to submit to reconstructive surgery *Operative treatment* 1) A bone-block was placed behind the elbow with the joint at a right-angle 2) The long head of triceps was detached from the olecranon and transplanted to the radius in front 3) The shoulder joint was arthrodesed in slight abduction These simple procedures improved the function of the limb so much that he secured work as a stenciller in a steel works, carrying his paint pot in the hook formed by the contracted fingers Pain disappeared and the circulation of the limb improved

CONCLUSIONS

After brachial plexus injuries, and other forms of paralysis of the upper limb, even when residual paralysis is very grave indeed, and even when the limb is almost flail—a forearm which can project forwards by the construction of a bone-block behind the elbow, with arthrodesis of the shoulder when necessary, a hand with fingers in the form of a claw and a thumb which opposes them, and a wrist which may perhaps be arthrodesed, but which still better can flex or extend when the forearm is pronated or supinated, together with the wise use of such muscles as are likely to gain function, may enable a patient to do very much more than he can with an artificial limb

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ARTHROPLASTY OF THE KNEE JOINT

Late Results

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Arthroplasty of the knee joint has not yet won general favour It is charged with failure to fulfil the hopes that were expected of it, namely, the attainment of perfect stability with sufficient and painless mobility Consequently many surgeons resort to it only in cases of absolute necessity However, the author's experience (1931, 1936) has been favourable, and the operation has been performed more than a hundred times for ankylosis, destruction of articular surfaces, and acquired or congenital deformities Seventy-two patients were operated upon between 1924 and 1941 which gives sufficient material by which to judge the merits of the method

Forty-three of these patients, twenty-eight women and fifteen men, have been re-examined recently Arthroplasty of both knees was performed in four cases and arthroplasty of the same knee twice in three, which accounts for a total of fifty operations in forty-three patients This study, and the statistics, refer to the number of operations and not to the number of patients

Technique of operation—Certain details of our operative technique require emphasis The same simple operation was used in all cases It is important to remove the tibial and femoral surfaces freely, and to retain in the middle of the tibial surface a ridge of bone 1 5 cm wide, which is introduced into the intercondylar groove shaped to receive it An attempt is always made to preserve the collateral ligaments, particularly the medial ligament, so as to prevent excessive lateral mobility There has never been need to lengthen the patellar tendon, and only once has a patella which was very thick and mis-shapen been removed This case is not included here, but the immediate result was well below the average The patient could neither brace his knee actively, nor lock it when bearing weight A free flap of fascia lata, about 15 cm by 10 cm in size, is used to cover the condylar surfaces, and it extends to the upper limit of the suprapatellar pouch A few years ago cellophane was used in two or three cases instead of fascia, it was either discharged spontaneously or had to be removed on account of the reaction it provoked

At first, private patients received passive physiotherapy after operation (diathermy, massage, etc), while public ward patients received no treatment other than active exercise of the quadriceps and forced mobilisation under anaesthesia Some fourteen years ago, these two groups of cases were compared, and we found no difference in the late results Passive treatment has, therefore, been discarded Infiltration of the knee with novocaine, enabling the patient to move the joint easily and with less pain, has proved useful Many of our patients received one to four mobilisations under anaesthesia within three or four months of operation This mobilisation, cautious and slow, was not carried beyond 20 to 25 degrees at any one time Mechanotherapy, bathing and early resumption of walking have also proved very useful

In four cases, all women, arthroplasty has been performed on both knees, but none succeeded in mobilising the second joint The effort needed for recovery from a second nearthrosis was beyond the capacity of the patient the bilateral operation has, therefore, been given up A second arthroplasty of the same knee has been performed in three women, reankylosis followed in two

The patient's age is important It is generally wise to wait until the age of twenty The young patient forgets too soon the promises of full co-operation which he originally made in his desire to regain mobility of the stiff joint The patient must be told of the pain he will

Paper read at the Joint Meeting of the Canadian, British, and American Orthopaedic Associations in Quebec June 1948

TABLE I

ANALYSIS OF ARTHROPLASTIES FOR ANKYLOSIS OF THE KNEE JOINT IN 43 PATIENTS OPERATED ON FROM 1924 TO 1941 *

	Cause of ankylosis	Case	Sex	Age	Duration (years)	Date of arthroplasty	Mobilisation under anaesthesia	Duration of physiotherapy (months)	Results (August 1946) Degree of flexion	Results (August 1946) Grading[1]
1	Acute suppurative arthritis	1 M H	M	16	1[illegible]	8/11/25	1	6	0°–90°	Ex
		2 E C	M	16	1[illegible]	19/7/27	0	2	0°–45	F
		5 M P	F	29	2	14/10/41	5	0	0°–90°	Ex
2	Acute arthritis	20 P L	F	21	10	4/2/28	2	0	0°–90	Ex
		11 F G	F	16	7	6/6/28	3	0	Reankylosis	P
		14 C L	F	20	5[illegible]	31/10/28	1	6	0°–90°	Ex
		26 C L	F	19	2	17/2/34	4	0	Reankylosis	P
		31 L G	F	22	2	11/6/34	2	0	0°–90	Ex
		30 C L	F	19	1	8/9/36	1	0	0°–70	Ex
		25 G S M	F	25	2	11/3/38	2	0	0°–90°	Ex
		17 M A	F	30	19	25/10/38	3	2	0°–90	Ex
		24 R G	M	23	1[illegible]	10/10/39	2	0	0°–45°	F
3	Gonococcal arthritis	23 J D	M	22	2	26/5/33	4	6	0°–90°	Ex
		22 J D C	F	38	1[illegible]	10/11/26	0	0	0°–90	Ex
		3 E T (bilateral)	F	31	1[illegible]	14/6/32 L	0	0	0°–70°	F
						1/9/33 R	0	0	Reankylosis	P
		23 J D	M	22	2	26/5/33	4	6	0°–90°	Ex
		41 J D	M	24	2	1/6/33	1	0	0°–90°	Ex
		29 E B	F	25	1	8/2/34	2	0	0°–90°	Ex
		42 G R	M	23	3	7/7/34	1	0	0°–35°	F
		15 J E P	F	38	2	8/8/34	0	0	0°–90°	Ex
		9 Y H	M	38	1[illegible]	23/10/34	2	12	0°–50°	F
		18 A L	M	29	29	23/5/35	1	2	0°–75°	Ex
		12 L F	F	26	[illegible]	10/10/35	0	0	0°–60°	F
		35 J C	F	23	[illegible]	2/2/36	1	0	0°–70°	Ex
		39 L D	F	34	4	31/7/36	0	0	0°–90°	Ex
		40 L B	F	32	13	11/11/36	1	0	0°–45°	F
		33 L T	M	34	4	6/6/37	1	0	0°–90°	Ex
		28 E V	M	34	3	11/6/37	1	0	0°–60°	Ex
4	Tuberculous arthritis	13 M L O	F	17	5	10/10/23	0	0	Reankylosis	P[2]
		7 O L	M	36	28	13/9/33	1	1	0°–90°	Ex
5	Polyarthritis	21 A F	M	35	2	26/1/34	1	0	0°–40°	F
		8 E B (bilateral)	F	22	12	30/7/35 R	4	0	0°–90°	Ex
						2/3/37 L			Reankylosis	P
		19 L F (bilateral)	F	60	20	14/10/37 R	1	0	10°–45° R	Ex
						15/1/38 L			10°–25° L	F
		16 E B	M	54	3	11/6/40	1	0	0°–90°	Ex
		10 J B	M	44	4	12/11/40	1	0	Reankylosis	P[3]
		4 A H (bilateral)	F	29	3	15/5/41 L	4	0	0°–40°	F
						11/9/42 R	—	—	Reankylosis	P
6	Hypertrophic chronic arthritis	37 E L	F	53	10	8/6/33	1	0	0°–60°	F
		38 J L B	M	48	5	13/6/35	0	0	0°–45°	F
7	Osteomyelitis (lower femur)	36 S C	F	24	6	2/4/36	0	0	0°–90°	P[4]
8	Fracture head of tibia	27 A D	M	60	2	10/12/32	1	0	0°–90°	Ex
		6 T T	M	39	$1\frac{6}{12}$	15/7/38	0	0	0°–90°	Ex
9	Unknown origin	34 L L	F	26	1	15/3/34	4	1	0°–60°	Ex
		43 F P	F	27	4	6/10/36	1	0	0°–40°	F

* In this table three cases in which a second arthroplasty of the same knee was performed (two of which resulted in reankylosis) are listed once only Thus there are 47 and not 50 results

[1] Grading Ex = Excellent, F = Fair P = Poor
[2] Absorption of lateral condyle
[3] Severe pain in hip joint
[4] Excellent for five years Late result poor

have to suffer for a fairly long time, otherwise he loses courage, abandons the treatment, and holds the surgeon responsible for the lack of success

Nature of ankylosis for which arthroplasty was performed—Among the forty-three patients, the causes of stiffness of the knee were gonococcal arthritis, 16, acute arthritis, 9, acute suppurative arthritis, 3, polyarthritis, 6, osteomyelitis, 1, tuberculosis, 2, chronic hypertrophic arthritis, 2, fracture of the head of the tibia, 2, and unknown, 2 It appears that bony and fibrous ankylosis respond equally favourably to arthroplasty In the case of osteomyelitis, suppuration took place and ankylosis recurred Oftentimes we were amazed to find that a patient whose new joint appeared in radiographs to be disorganised leads nevertheless a fairly normal life

Fig 1

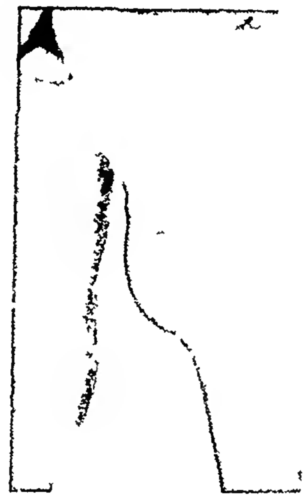

Fig 2

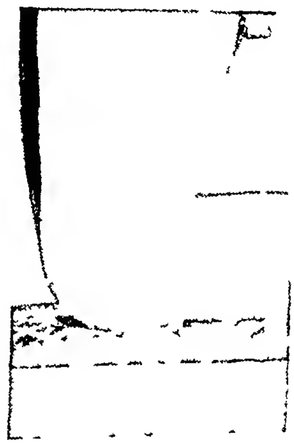

Fig 3

Eight years after arthroplasty for bony ankylosis of the knee joint Despite "the appearance of anarchy" in the radiograph (Fig 1) the function is excellent, there is 90 degrees of movement and the patient leads a fairly normal life

Results—The results of fifty arthroplasties performed in forty-three patients are shown in Table I They may be summarised thus

Excellent—with a range of flexion movement to between 45 and 90 degrees, and a stable and painless joint—twenty-six (52 per cent)

Fair or Poor—including those who gained less than 45 degrees of movement (though with a stable and painless joint) and those in whom there was reankylosis, instability, or persistent pain—twenty-one (48 per cent)

Summary—These statistics show that some movement was gained, with good stability and painlessness, in thirty-five of the fifty operations (70 per cent) and that there was failure, with reankylosis, instability, or persistent pain, in fifteen (30 per cent)

CONCLUSIONS

1 Arthroplasty of the knee is a worth-while operation
2 When performed under aseptic conditions it carries no important risks
3 Ankylosis of gonococcal origin seems to be the most frequent of all indications
4 In polyarthritis one must be certain that the disease is quiescent before operating
5 Osteomyelitis and tuberculosis, however long inactive, are contra-indications
6 The musculature controlling the knee must be healthy
7 The co-operation of the patient is indispensable

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ARTHROPLASTY OF THE KNEE

A Follow-up Study

J. S. Speed and Philip C. Trout, Memphis, Tennessee*

From the Campbell Clinic, Memphis

In this paper the results of a follow-up study of fascial arthroplasties of the knee joint which have been performed at the Campbell Clinic are presented, together with generalisations regarding the operation which from our experience seem justified. Ankylosis of the knee is not a crippling deformity and for this reason most orthopaedic surgeons agree that a knee which is stiff in good functional position is preferable to the uncertainties of arthroplasty. It is the authors' opinion, based upon this study, that in properly selected cases arthroplasty of the knee offers a practical method of relief from a disabling deformity which is a constant source of annoyance and embarrassment, particularly in women. In such cases, the patient should have a reasonable expectation of obtaining: 1) between 60 and 90 degrees of active movement with adequate muscular control; 2) sufficient stability to permit ordinary activity without the use of external support; 3) no pain, or pain of such minor degree as not to limit an average day's work in occupations other than those involving manual labour.

INDICATIONS FOR ARTHROPLASTY OF THE KNEE

Arthroplasty is indicated in patients with fibrous or bony ankylosis of the knee, between the ages of bone maturity and fifty years, who are not required to perform manual labour and in whom the ankylosis is the result of: 1) acute infective arthritis of haematogenous origin; 2) suppurative arthritis from punctured wounds or open fractures, the infection having been limited to the joint and unassociated with osteomyelitis; 3) trauma followed by incomplete painful ankylosis or complete ankylosis, wherein the bony components of the joint are not materially disturbed.

Formerly, most arthroplasties were performed for ankylosis from acute infective arthritis, usually of a gonorrheal nature, or punctured wounds of joints. Recent advances in the treatment of acute infections by sulphonamide drugs and antibiotics has considerably reduced the incidence of ankylosis from these sources.

CONTRA-INDICATIONS TO ARTHROPLASTY OF THE KNEE

Arthroplasty is contra-indicated when ankylosis of the knee is incident to, or associated with: 1) multiple rheumatoid arthritis; 2) tuberculosis; 3) osteomyelitis, either haematogenous or associated with open fractures; 4) obesity; 5) osteoporosis. Although we still advise arthroplasty of the knee for certain severely disabled patients with multiple ankyloses from rheumatoid arthritis, the purpose of the operation is not the same, nor do we expect as good results as in the favourable group. Osteoporosis provides a poor type of bone for the reconstruction of a weight-bearing joint. Erosion and absorption of the articular surfaces often cause instability, and valgus or varus deformities. The operation should be postponed, and active weight-bearing encouraged, until recalcification is adequate.

One hundred and seventy-six fascial arthroplasties of the knee were performed by various members of our staff before 1947. In the beginning, the indications and contra-indications were not clearly understood, and the operation was performed upon many patients who, to-day, would not be considered suitable subjects. Such cases have been excluded from this study, not with the object of improving end-result statistics but simply because they

* *Paper read at the combined meeting of the American, British and Canadian Orthopaedic Associations in Quebec, June 1948, with cinematographic demonstration.*

did not contribute to the solution of the fundamental problem—that is to say, the value of the operation in the type of case which we now regard as appropriate for fascial arthroplasty

The early arthroplasties, wherein chromicised pig's bladder was used, were failures Of four cases in which a single fixed vitallium mould was placed over the lower end of the femur, only one was successful The patients in these two groups are not included in the present review The failures after the use of the vitallium mould are explained by the fact, as shown by Smith-Petersen, that if a foreign body mould is to function satisfactorily it must be freely movable within the joint, fixation to either articular surface defeats the purpose of the mould In the four cases in question, an active fibrous tissue and bony irritative reaction took place, the free surface of the mould becoming partly covered with a pannus-like formation of new bone It was hoped that early removal of the mould might terminate this reaction, but in only one of the four cases was the process arrested before ankylosis recurred

The development of a satisfactory mould should increase the number of good results in that group of cases in which we now consider that arthroplasty of the knee joint is indicated, and perhaps widen the scope of the operation to include a large group of patients with ankylosis of the knee due to rheumatoid arthritis

BIOLOGICAL AND ADAPTIVE CHANGES AFTER ARTHROPLASTY

Our experience with fascial arthroplasties of both hip and knee joints has led us to the conclusion that certain biological and adaptive changes are constantly taking place, so that one can never say that an end-result has been achieved Nevertheless, follow-up studies have shown that, after fascial arthroplasty of the hip joint, function usually deteriorates adually over a period of years, whereas, after arthroplasty of the knee joint, function reaches maximum after five to ten years and subsequently remains remarkably stable For this eason, a follow-up period of at least five years is believed to be necessary for proper estimation of the functional results

In view of the fact that many real or apparent failures manifest themselves within the first five years, a conscientious effort has been made to trace by correspondence or re-examination every patient who had a fascial arthroplasty and who was considered suitable according to our present criteria Of the patients in this group, sixty-five were traced for five or more years after operation, one hundred and eleven were not traced, or were considered unsuitable

The pathological processes responsible for ankylosis in the sixty-five suitable cases were of three types Neisserian infection, haematogenous infection other than Neisserian suppurative arthritis, and traumatic arthritis Until recent years, gonorrheal arthritis was the most common cause of monarticular ankylosis, and the infection was never reactivated at the time of operation If the etiological factor was a blood-borne infection other than gonorrhea, the pathological process was classified as infective arthritis Ankylosis from suppurative arthritis includes those cases in which the infecting organism, usually the staphylococcus or streptococcus, was introduced directly into the joint by a penetrating wound or surgical arthrotomy In this group, the articular cartilage was destroyed rapidly, thus giving rise to early ankylosis Injury without infection, except in the elbow, is seldom responsible for complete ankylosis Nevertheless, arthroplasty is often indicated for the relief of pain in an injured joint with incongruous surfaces, or one in which movement is blocked because of comminution of the articular surfaces

SURGICAL TREATMENT

The Campbell technique of arthroplasty of the knee has been employed exclusively in this group of cases Some of the fundamental principles which experience has proved to be sound are 1) The simplest type of hinge joint should be constructed, with single broad

Case 1 Radiograph twenty-three years after arthroplasty of knee

A

B

C

Case 1 Range of movement from 180 to 110 degrees

D

F

H

E

G

I

D E—Weight-bearing in extension and flexion

F, G—Ascending stairs in normal stride

H I—Descending stairs in normal stride

FIG 1

Case 1 Fascial arthroplasty of the left knee for bony ankylosis due to acute infective arthritis re-examined twenty-three years after operation The radiographs are shown above There is 70 degrees of movement from 180 to 110 degrees (A B C) The knee is stable and free from pain (D E) The patient can go up and down steps normally (F G H, I) and she can *walk eight or ten miles a day*

femoral and tibial condyles The formation of a tibial spine (Putti) or a wedge-shaped femoral condyle (Haas) increases the likelihood of incongruity of the articular surfaces, since they require that nature shall accomplish by adaptive processes a relationship between the articular surfaces which can be achieved at operation 2) The extensor mechanism should be disturbed as little as possible, hence, division of the quadriceps tendon or detachment of the insertion of the patellar tendon is unwise Adequate exposure may be obtained without either of these procedures 3) Sufficient bone should be removed from the posterior parts of the femoral condyles to permit free movement of the tibia well up into the popliteal space 4) In ankylosis of one-half the joint, the other half being relatively normal and with intact articular cartilage, a hemi-arthroplasty limited to the ankylosed side is contra-indicated Without exception, this procedure has been a failure 5) The use of a fascial covering of the new joint may not be necessary, but it is of value in keeping the bone surfaces separated until they are covered with fibrocartilage 6) The ultimate stability of the joint depends upon *a*) wide weight-bearing surfaces of the tibia and femur, *b*) ligamentous and muscular support The collateral ligaments and joint capsule should be stripped carefully from the bone and preserved The cruciate ligaments, if present, must be sacrificed

RESULTS OF ARTHROPLASTY

The reconstruction problem and the operative technique are identical in fibrous and bony ankylosis The practical value of an arthroplasty to the patient must be judged by the function obtained One can form a true estimate of the functional capacity only by observing the patient walk, and go up and down steps, and by knowing how well the joint withstands the demands of an ordinary day's work Printed words and tables cannot convey this information, even the moving pictures which accompanied presentation of this article were inadequate to demonstrate the satisfaction which 70 per cent of these patients derived from the operation The estimate of results was based upon the range of movement, stability, position of the knee in extension, and the amount of pain which the patient experienced with average use of the knee

Range of movement—An arthroplasty of the knee is most efficient and durable if the range of movement gained is between 70 and 90 degrees (from 180 degrees to between 110 degrees and 90 degrees) Movement beyond 90 degrees may produce instability Sixty degrees gives a good functional joint, except for going up and down stairs Movement of 40 to 60 degrees is considered fair, patients with this range can walk without a limp and sit in a chair without being conspicuous If movement is less than 40 degrees, the result is regarded as poor Nevertheless, all patients in this group who failed to obtain the maximum range of movement preferred even the limited range to a stiff joint, and none wished to be deprived of the mobility which had been gained Analysis of the sixty-five cases showed that the range of movement was 60 degrees or more in half the cases (Table I)

Stability—Stability is both an anatomical and a functional equation Good stability is that degree which permits ordinary activity Most patients in this study had a little increase in lateral or antero-posterior mobility when the joint was flexed, but all had good stability in extension with the quadriceps contracted In those who were regarded as having fair stability there was some definite abnormal mobility and the joint was incompletely stabilised by quadriceps contraction These patients found it necessary to be careful while walking, but required no external support Patients who complained that their knees often " gave away," and those who had such abnormal mobility as to necessitate external support were regarded as having poor stability On this basis it was found that two-thirds of the cases gained good stability, in one-third there was fair or poor stability or reankylosis (Table II)

Alignment when weight-bearing—The position of the extended knees in weight-bearing showed normal alignment in half the cases, some valgus deformity in nearly one-third, and varus or recurvatum in a few cases (Table III)

Pain—It was interesting to observe how few patients had pain There was often considerable grating on active movement of the joint, and such irregularity of the articular surfaces was demonstrated, not only on physical but on radiographic examination, that one might well have expected movement of the knee to be extremely painful As shown in Table IV, however, pain was no real handicap

TABLE I

RANGE OF MOVEMENT AFTER ARTHROPLASTY

	Cases	
Good (60° or more)	36	55 4%
Fair (60° to 40°)	12	18 5%
Poor (40° or less)	9	13 8%
Reankylosis	8	12 3%
	65	100 0%

TABLE II

STABILITY OF THE KNEE AFTER ARTHROPLASTY

	Cases	
Good	44	67 7%
Fair	8	12 3%
Poor	5	7 7%
Reankylosis	8	12 3%
	65	100 0%

TABLE III

WEIGHT BEARING ALIGNMENT AFTER ARTHROPLASTY

	Cases	
Straight	32	49 0%
Valgus	19	30 0%
Varus	4	6 0%
Recurvatum	2	3 0%
Not included (reankylosis)	8	12 0%
	65	100 0%

TABLE IV

PAIN AFTER ARTHROPLASTY

	Cases	
None	22	34 0%
Slight	27	41 4%
Moderate	8	12 3%
Reankylosis	8	12 3%
	65	100 0%

TABLE V

RESULTS OF ARTHROPLASTY OF THE KNEE

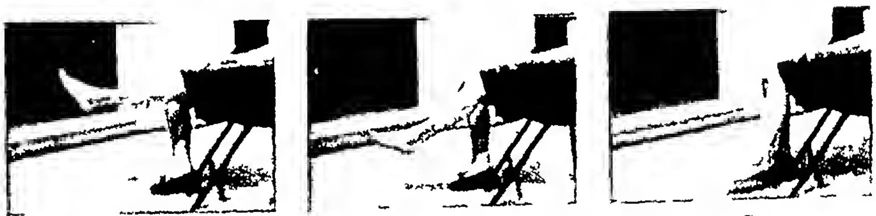
	Cases	
Good	29	44 6%
Fair	17	26 2%
Poor	6	9 2%
Failure	13	20 0%
	65	100 0%

COMPOSITE ESTIMATE OF RESULTS

Patients who were regarded as having gained a good result had a range of movement of 60 degrees or more, slight or no pain, adequate stability, and a good weight-bearing position of the joint Those with fair results had from 40 to 60 degrees of movement, with or without moderate pain, adequate stability and a good weight-bearing position The results were considered to be poor in patients who had less than 40 degrees of movement, or in whom there was instability, or a faulty weight-bearing position of the joint The operation was classified as a failure in those who had recurrence of ankylosis or for whom surgical reankylosis was necessary because of instability and pain (two cases)

It is appreciated that the personal equation of the examiner is an important element in final estimation of results A sincere effort has been made to assess accurately the results of the fascial arthroplasties of the knee which we have performed in the sixty-five cases considered suitable for the operation These results are shown in Table V

Case 2 Radiographs twenty-one years after arthroplasty of knee



A B C

Range of movement from 180 to 100 degrees

FIG 2

Case 2 Fascial arthroplasty of the left knee for bony ankylosis due to acute infective arthritis followed-up twenty-one years after operation The radiographs are shown above There is active and passive movement from 180 to 100 degrees (A, B C) She carries on with all ordinary physical activities including standing at work for eight hours a day and has no instability and no pain

SUMMARY

1 Arthroplasty of the knee joint should be performed only in carefully selected cases Criteria for the operation are outlined

2 In our experience, 70 per cent of properly selected patients secure good or fair results An additional 12 per cent, whose anatomical or functional results were classified as poor, preferred the movement which had been gained to ankylosis of the joint

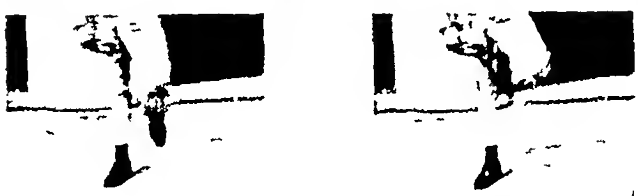
3 The major functional adaptation of the knee joint takes place during the first five years after arthroplasty Several patients who had a poor range of movement after one or two years developed an excellent range by the end of five years

4 Instability, when present, usually became apparent within the first five years

5 Joints which were still stable at the end of five years usually remained so over a long period of time Four patients have been traced for twenty to twenty-five years, and three have been traced for over twenty-five years

6 Since the incidence of ankylosis of the knee joint from gonococcal and pyogenic infections has been reduced by the use of antibiotics, fewer patients are suitable subjects for arthroplasty

Case 3 Radiographs fifteen years after arthroplasty of knee



A B

Case 3 Weight-bearing on affected limb showing stability

C D E

Range of movement from 180 to 90 degrees

Fig 3

Case 3 Fascial arthroplasty of right knee for fibrous ankylosis due to acute infective arthritis followed-up fifteen years after operation The radiographs are above There is excellent stability (A B) and movement from 180 to 90 degrees (C D E) This patient did not secure the maximal range of movement until ten years after operation

DISCUSSION

Sir Reginald Watson-Jones (London, England)—I feel sure that the reason I have been invited to discuss these papers from two famous clinics—the Campbell clinic, and the clinic of Dr Samson in Montreal—must be that I am known to be a staunch exponent of arthrodesis rather than arthroplasty of the weight-bearing joints It is all very well for a patient who has been subjected to arthroplasty to sit in a chair and demonstrate movement—but can he walk ten miles and can he jump from a five-barred gate? These are the criteria which I demand and no doubt it was thought wise that discussion should be sought from an unbeliever I would admit at once that whereas complete success in arthrodesis of the ankle joint depends on free mobility of the subastragaloid and mid-tarsal joints and whereas success in arthrodesis of the hip joint demands free mobility of the pelvis and of the opposite hip so that the arthrodesed joint does not appear to be stiff at all arthrodesis of the knee joint causes obvious stiffening which cannot be concealed No neighbouring joint is available to take over function and the disability is indeed very great

I have known patients to say that they would prefer amputation and an artificial limb to complete stiffness of the knee joint If there ever was indication for arthroplasty of a weight-bearing joint it would be in the knee

Unfortunately however, the problem of arthroplasty of the knee joint is infinitely greater than that of arthroplasty of the hip When the purpose of a mobilising operation is to gain movement in every direction, as in the case of the ball-and-socket joint of the hip it can be secured with relative certainty by ruthless excision of bone, burning of raw surfaces and interposition of a metal cap of rounded shape But when the purpose of operation is to secure free movement in one direction and perfect stability in the other the problem is entirely different It must be acknowledged that success in operative mobilisation of the hip joint—limited as it may be—has not yet been equalled or even approached by operative procedures which hope to achieve stable mobilisation of the knee joint

The careful studies of Dr Boyd Dr Speed Dr Trout and Dr Samson must lead us to one conclusion Even in the hands of these great experts and even in carefully selected cases—selected not only by reason of the type of ankylosis and the ability of the patient to co-operate in difficult and painful after-treatment but also by reason of the limited activities which the patient proposes to pursue—no more than about 50 per cent of cases are successful There can be no doubt that this procedure is still in an experimental stage It is most important that the pioneer work of the Campbell clinic should continue and we hope that Dr Samson s results will be recorded in even more accurate detail But when it is recognised that after careful selection and in the hands of experts, success is to be expected in no more than about half the cases, is it not wise for those of us who are less expert and less experienced to hesitate?

My own practice has been to reserve arthroplasty of the knee joint for patients with multiple ankyloses —ankylosis of both knee joints and ankylosis of the knee and hip joints of the same limb I am quite prepared to believe that some day the pioneers will prove a much wider application than this, but meanwhile, conservatism may be *justified* We know the limitation of arthrodesis but at the same time we are sure of its success and it is not every patient who is prepared to accept the pain of operation and the discomfort of after-treatment without some definite promise of the end-result which is to be achieved Are we, as yet in a position to make such promise for arthroplasty of the knee joint?

Dr Joseph Freiberg (Cincinnati Ohio)—I wish to show the records of a patient fifteen years after arthroplasty of the knee for ankylosis due to acute infective arthritis after compound fractures of the upper third of the tibia, associated with extensive thrombo-phlebitis of the limb In 1933 an arthroplasty of the Campbell type, which I have long preferred, was performed This man is now forty-one years old and he is still playing tennis There is 80 degrees of painless stable movement He is more than enthusiastic about his knee joint The excellence of the result is shown in these slides I have a number of other good arthroplasties of the knee but this particular case is presented in order to show that when carefully done, and in well-selected cases the operation is well worth while

Dr Mather Cleveland (New York)—We are impressed with the movies which have been assembled by Dr Speed they show beautiful end-results Dr Samson s end-results too, are impressive But when you consider that Dr Speed is reporting no more than one-third of all knee joints in which arthroplasty has been attempted, discarding two-thirds for various reasons, and that less than 50 per cent of those which are reported have yielded good, or better, results I believe that we must pause for a word of caution This operation may be a booby-trap for the unwary surgeon Having served as consultant in the Armed Forces, and having all too often observed the enthusiasm with which a young man may be led into trouble by the written word, I believe that it would be wise for Dr Speed and Dr Samson to stress the difficulties and perhaps talk more about the possibilities of failure than about the beautiful results which are all too infrequent I hope that both these authors will indicate the pitfalls and the dangers which are inherent in these surgical procedures, as well as the advantages which may be gained when there is satisfying success Perhaps at another time they will show us moving pictures of one or two of their failures

Dr Harold Boyd (Memphis, Tennessee, for Dr Speed)—I am sorry that the absence of Dr Speed in Hawaii has made it impossible for him to reply in person Sir Reginald does not favour arthroplasty of the knee joint because patients are not able to run ten or twelve miles and jump from five-barred gates But we must not ask too much of arthroplasty, many of us, who think that we are normal, cannot perform such feats, and it is not the purpose of this operation to improve the athletic abilities of the patient It is true that arthrodesis of the knee joint is better suited to many cases than arthroplasty—and indeed we perform arthrodesis more often than arthroplasty—but this does not imply that in properly selected cases arthroplasty does not have its place Stability is important, and we respect it in our British friends, but in this country we may perhaps be allowed to think that stability alone is not enough

Significant points were discussed by Dr Bennett Dr Cleveland and Dr Freiberg May I say that it was not the purpose of this contribution to dissuade surgeons from arthrodesis of the knee joint in favour of arthroplasty? The problem was presented to this Association in former years by Dr Campbell, and it was believed that the findings of late follow-up study should be recorded We have no doubt that in properly selected cases the operation has a definite place in orthopaedic surgery, and that these suitable cases are entitled to the benefits which can be derived from the procedure

INTRATHORACIC DISLOCATION OF THE HUMERUS

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From the Orthopaedic Department of the Royal Adelaide Hospital

The patient was a Chinese man aged twenty-seven years, he was a carpenter employed in boat-building At the time of the accident, in September 1945, he was using a brace and bit and standing on a plank at the side of a boat, which was on an elevated stage The plank gave way and he fell to the ground, a distance of approximately twenty feet His outstretched right arm struck another plank as he fell, and he then fell on to the outstretched limb There were no other injuries except to the right shoulder The medical attendant who was called found that the limb was projecting horizontally from the body and the patient

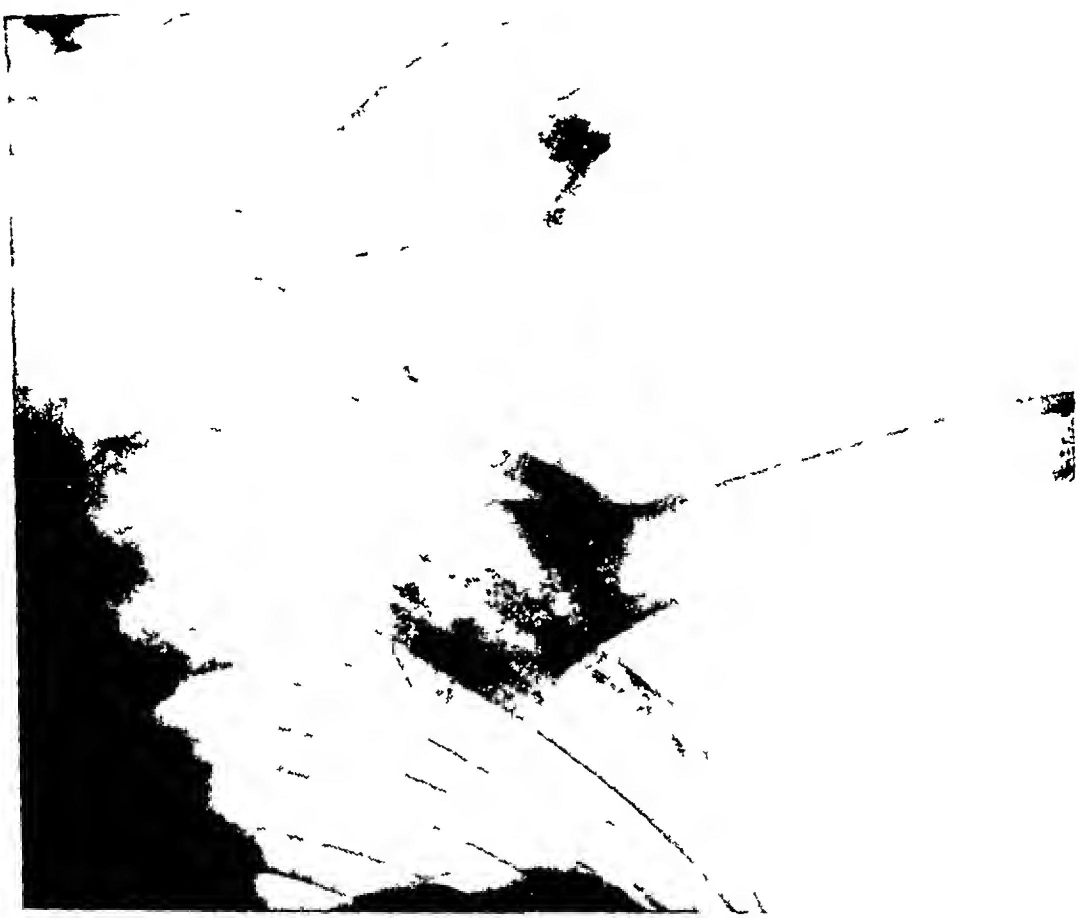

Fig 1

Intrathoracic dislocation of the humerus The surgical neck of the humerus was gripped between the third and fourth ribs When it was pulled out of the chest cavity, the sensation was that of extracting a large cork from a bottle

resented any movement He was admitted to hospital four hours later There was obvious prominence of the acromion process and downward displacement of the head of the humerus Surgical emphysema was present over the whole of the anterior chest wall No nerve lesion could be detected Radiographs showed that the head of the humerus was displaced from the glenoid cavity and lay inside the thoracic cavity, the surgical neck being gripped between the third and fourth ribs (Fig 1) A large fragment had been avulsed from the greater tuberosity and remained approximately in its normal position

Horizontal traction was made on the limb under general anaesthesia The head of the humerus was felt to slip out of the chest cavity, the sensation was similar to that of extracting a large cork from a bottle When the limb was brought to the side the head of the humerus returned to the subcoracoid position and was quite easily replaced in the glenoid cavity by Kocher's method (Fig 2) The limb was bandaged to the side for four weeks, after which it was gradually brought up into abduction Active movements were encouraged and the final result was satisfactory A full range of rotation was regained, but abduction was limited to a little beyond the horizontal on account of displacement of the fragment of the greater tuberosity He returned to work as a carpenter six months after the date of injury

Fig 2

After applying traction, the limb was brought to the side The head of the humerus returned to the subcoracoid position and was replaced easily in the glenoid by Kocher's method

A search of the literature has failed to reveal any record of a similar displacement of the humeral head in cases of dislocation of the shoulder joint It is believed that in forcibly striking the outstretched limb against an object, while falling vertically, violent abduction forced the humeral head through the lowest and weakest part of the capsule to the level of the third and fourth rib interspace, and that in falling on the outstretched hand he then drove the head of the humerus between the ribs into the thoracic cavity The pleura was injured—as evidenced by the surgical emphysema The greater tuberosity was doubtless avulsed by the supraspinatus tendon One of the remarkable features of the case was the absence of nerve injury It was also surprising that the dislocation was reduced so easily

PREMATURE EPIPHYSIAL FUSION AT THE KNEE JOINT IN TUBERCULOUS DISEASE OF THE HIP

W PARKE, G S COLVIN, and A H G ALMOND, LIVERPOOL, ENGLAND

The treatment of tuberculous disease of the hip in children has not yet reached the stage when useful recovery of joint function is a frequent end-result Brackett (1924) urged that the first objective should be the provision of a permanently safe and useful limb, and in girls, we would add, a graceful one These standards are not achieved, even with quiescent disease and a soundly ankylosed joint, if there has been arrest of limb growth at an early age As long ago as 1899 Sir Robert Jones estimated the frequency of this complication to be in the region of 15 per cent , but it was not until 1944 that Gill showed that it was caused by premature epiphysial fusion at the knee joint and drew further attention to the severity of the disability

This review was undertaken to determine the present incidence of premature epiphysial fusion in children who had been treated for tuberculous disease of the hip by prolonged conservative measures, and to study the relationship of this complication to the disease, the changes which precede and accompany premature fusion, and the possibilities of earlier recognition and prevention

The patients were treated at four hospitals in the Liverpool area Alder Hey Children's Hospital, Liverpool Open-Air Hospital, Royal Liverpool Children's Hospital, and Wrightington Hospital The study included all patients with tuberculous disease of the hip joint who were in-patients of these hospitals during 1947, except those in whom the disease first began after the age of fifteen years There were ninety-one diseased hips in ninety patients—forty-two right, forty-nine left, forty-seven male, forty-four female, with a duration of disease varying from four months to twenty-two years In addition to general study of the clinical and radiographic findings the examination included individual mensuration of the long bones, and X-ray films of both hips, both knees, and both ankles

CLINICAL EVIDENCE OF PREMATURE FUSION

The later stages of premature epiphysial fusion, so well described by Gill (1944), Kestler (1947), and Ross (1948), are recognised easily by deformity at the knee and measurable shortening We were unable to discover any reliable clinical sign of early fusion in limbs with equal bone length and without deformity There were, however, definite clinical signs of osteoporosis which, as will be seen later, is considered to be a necessary forerunner of premature fusion Knees which have been immobilised for one year or more show well-marked tenderness of the bones to pressure—tenderness which bears a direct relationship to the degree of osteoporosis In one case, with moderate pressure, it was possible to indent the cortical bone over the lateral condyle of the femur, release of pressure resulted in recoil as would an old ping-pong ball These signs are evidence of no more than osteoporosis which may not yet be associated with premature fusion Conversely, bones which show indisputable evidence of premature fusion are not always tender, in such cases radiographic examination shows that reformation of bone has occurred with dense and irregular trabeculation Circumferential limb measurements were found to be of no diagnostic value

RADIOGRAPHIC EVIDENCE OF EARLY PREMATURE FUSION

The complication is always preceded by intense porosis of the bones at the knee The earliest stage is shown by flame-shaped areas of increased translucency in the diaphyses and epiphyses, with their apices at the points of entry of the nutrient arteries and their bases on the articular cartilage (Fig 1) With further resorption of bone there is marked loss of

FIG 1A

FIG 1B

FIG 1C

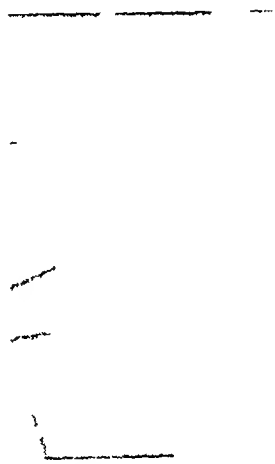

FIG 1D

Case 80 Disease of the right hip joint, showing osteoporotic and toxaemic changes in the region of the right knee

FIG 2A

FIG 2B

Case 43 Disease of the left hip joint, showing central areas of resorption in the lower femoral and upper tibial epiphyses of the left knee

transverse trabeculation This is more evident in the diaphyses some distance from the epiphysial lines where the medullary bone takes on a frosted glass or irregular honeycomb appearance There is also thinning of the cortical bone At this stage it is often found that the circumferential size of the bones on the affected side is smaller, and the vertical depth of the epiphysial plates reduced On the normal side the bones show less marked porosis, and their size and the depth of the epiphysial plates remain unchanged (Fig 1)

The apparent solution of transverse trabeculation brings into focus the finer points of the longitudinal trabecular architecture of the epiphyses In the tibial epiphysis this consists of oblique cancellous struts which pass from the near-central area of the terminal bone plate to the articular cartilage of the opposite condyle, with an infero-medial decussation Laterally they are less oblique, do not cross, and pass almost vertically to the condyle of the same side In the lateral view the struts are situated behind the centre, they pass upwards and forwards

FIG 3

Case 25 Disease of the hip joint, showing the first stages of a bulge into the area of resorption in the tibial epiphysis

to the articular cartilage and are continuous with similarly arranged struts in the diaphysis The femoral epiphysis is strengthened by two bars which pass vertically downwards from the terminal bone plate to the articular cartilage of each condyle, which likewise are stronger posteriorly and continuous with similarly arranged struts in the diaphyses (Fig 4) Increasing osteoporosis gives rise to resorption of the longitudinal trabeculation in the weakest places, with the formation of completely translucent areas in the epiphyses and occasionally in the diaphyses (Fig 2) Their appearance heralds the approach of premature fusion Subsequent changes at the femoral and tibial epiphysial lines are not identical and will be described separately

"Bulge type" of fusion—In the tibial epiphysis, a central translucent area appears to the inner side of the mid-line above the point of strut decussation, and enlarges upwards towards the articular cartilage and downwards towards the terminal bone plate (Fig 3) The terminal bone plate, the thinned cartilaginous plate, and the growth retardation line, together with

FIG 4A

FIG 4B

Case 77 Disease of the left hip joint with an unruptured bulge into the left upper tibial epiphysis On the right side it is seen that longitudinal trabecular architecture is prominent

FIG 5A

FIG 5B

Case 84 Disease of the right hip joint with an unruptured bulge into the right upper tibial epiphysis of more than five years' duration there is negligible interference with growth

the medullary contents of the shaft, then bulge upwards into this translucent area (Fig 4) This may be termed the pre-fusion stage because premature fusion, though likely to follow, is not inevitable A tibial bulge which must have been present for more than five years is shown in Fig 5, the epiphysial line is grossly distorted but the translucent cartilaginous plate can still be traced over the bulge, and there is no marked interference with growth

Premature fusion is inevitable when the limiting structures of the bulge rupture, and turn up like a flap into the translucent area in the epiphysis (Fig 6) This allows the semi-

FIG 6A

FIG 6B

Case 38 Disease of the right hip joint showing a bulge into the right upper tibial epiphysis with rupture, and fragmentary fusion of the right lower femoral epiphysis

fluid medullary contents of epiphysis and diaphysis to intermingle and establish a channel through which the blood supply of both can become continuous, now that the barrier of avascular cartilage has been removed The laying down of bone trabeculae through this channel is not seen until a later date

"Fragmentary type" of fusion—This type of fusion occurs more frequently in the femur, and is preceded by the same intense osteoporosis Translucent areas appear, centrally in the diaphysis of the femur, and both subcortically and centrally in the epiphysis Subcortical

resorption occurs on the peripheral aspect of the vertical cancellous struts and does not abut to any extent on the terminal bone plate The central translucent areas, both in epiphysis and diaphysis, are situated between the two cancellous struts and are larger, but less defined, than in the tibia Premature fusion is indicated by the appearance of many small isolated fragments of calcific material replacing the crenated line of the terminal bone plate which normally is well defined and continuous *The thinned epiphysial cartilage plate* disappears altogether in the area affected, and irregular linear shadows may be seen in the diaphysis (Fig 6) In some cases there was difficulty in making certain that the cartilaginous plate was in fact obliterated, and that a false appearance was not being created by overlapping shadows Oblique films were sometimes helpful but, where the evidence was still uncertain, repeated radiographic examination was made of the epiphysial lines In securing early evidence of fusion, this was more valuable than radiographic estimations of bone length

TABLE I

FREQUENCY AND TYPE OF PREMATURE EPIPHYSIAL FUSION AT THE IPSILATERAL KNEE IN 91 HIPS WITH TUBERCULOSIS IN 29 CASES FROM A TOTAL OF 91 TUBERCULOUS HIP JOINTS

Bones involved	Tibia		Femur	
	Alone 12	With femur 14	Alone 3	With tibia 14
Total frequency	26		17	
Site and type of change [B=Bulge F=Fragmentary]	Postero-medial 17 (B); Antero-medial 2 (B); Central 2 (B); Lateral 3 (F); Antero-lateral 2 (F)		Postero-central 14 (F); Central 2 (F); Lateral 1 (F)	

ANALYSIS OF PREMATURE EPIPHYSIAL FUSIONS

In this series of ninety-one tuberculous hip joints there were twenty-nine cases of premature fusion at the ipsilateral knee fifteen right, fourteen left, fifteen male, and fourteen female They have been divided into three groups according to the duration of epiphysial fusion 1) *late fusions*—fifteen cases, all with radiographic evidence of a bone lock between epiphysis and diaphysis, 2) *early fusions*—eight cases, with ruptured bulges or fragmentary changes without evidence of a bone lock, in this group there was no deformity and no shortening, 3) *doubtful fusions*—six cases, with unruptured bulges or fragmentary changes in which evidence of destruction of the cartilaginous plate was uncertain (these have since been followed up for a year and all have fused)

Table I shows the frequency, type, and site of premature fusion The tibial epiphysis was involved in twenty-six patients, and the femoral epiphysis in seventeen Both bones were affected in fourteen cases, the tibia alone in twelve, and the femur alone in three The bulge type of fusion was responsible for twenty-one out of twenty-six tibial fusions The site of the original bulge was always postero-medial but, as it enlarged, extension took place anteriorly and laterally Fragmentary types made up the remainder of the tibial fusions and they were confined to the antero-lateral or lateral portions of the epiphysial plate Only the fragmentary type was seen in the femur The change occurred postero-centrally or centrally in sixteen out of seventeen cases, and in the lateral half of the plate in the remaining

case In all, there were six patients with changes limited to the lateral half of the cartilaginous plates, but in no case in the series was the medial half affected alone

With one exception, the femoral and tibial epiphyses in the normal limb did not show evidence of premature fusion, neither did the epiphyses at the ankle, or at the upper end of the fibula, even on the diseased side

Relation of the duration of hip disease to premature fusion—In Table II the cases are classified according to the duration of hip disease Of twenty-seven patients with disease of less than two years' duration, not one had either positive or doubtful evidence of premature fusion There were thirty-six cases with a history of three to five years of disease and, with one exception, this group included all the examples of doubtful and early fusion Of the twenty-one cases with disease lasting from six to ten years, there were nine with evidence of late epiphysial fusion and no examples of early or doubtful fusion Every one of the seven cases

TABLE II

INCIDENCE OF PREMATURE EPIPHYSIAL FUSION COMPARED WITH DURATION OF HIP DISEASE

Duration of hip disease	Number of cases	Premature fusions		
		Doubtful	Early	Late
First year of disease	7	—	—	—
Second year of disease	20	—	—	—
Third year of disease	15	4	3	—
Fourth year of disease	9	—	2	—
Fifth year of disease	12	2	2	—
Sixth to tenth year of disease	21	—	—	9
Eleventh to twentieth year of disease	6	—	1	5
Over twentieth year of disease	1	—	—	1
Total	91	6	8	15

with a history of more than ten years showed premature fusion, six late and one early, the one case with early evidence of epiphysial change was an example of remission of hip disease after six years of complete freedom It would seem that premature fusion does not occur during the first two years of the disease, and that early fusion develops some time between the third and fifth years

Relationship of the age of the patient to premature fusion—The liability to premature fusion is not influenced by the age of the patient at the time of onset of hip disease Every age group, up to thirteen years, was similarly affected

Relationship of the severity of hip disease to premature fusion—In attempting to determine whether or not premature fusion was related to the severity of disease, the cases were classified into four groups 1) typical disease, with early and marked destruction of the femoral head, acetabulum, or both, 2) low grade infection, without much bone destruction, but with recurrences and exacerbations, 3) extra-articular bone infection, with no evidence of joint involvement, 4) synovial tuberculosis with persistent osteoporosis In Table III the incidence of premature fusion in the different types of disease is analysed, and it is evident that there is a close relationship with the severity It occurs least frequently in extra-articular and synovial tuberculosis, and most frequently when there is typical disease with marked destruction of bone, especially when complicated by persistent sinus formation

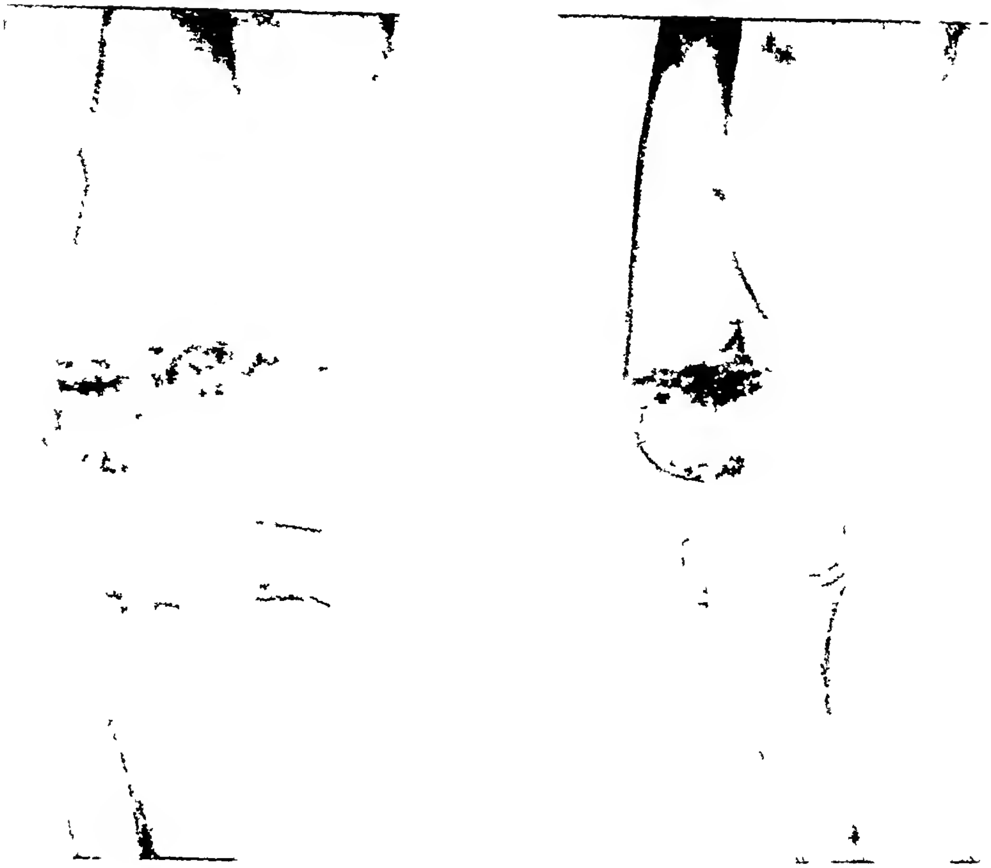

FIG 7

Case 19 Disease of the left hip joint A fracture was sustained through the lower third of the shaft of the femur Radiographs taken at the time of fracture show that there was already a ruptured bulge in the upper tibial epiphysis

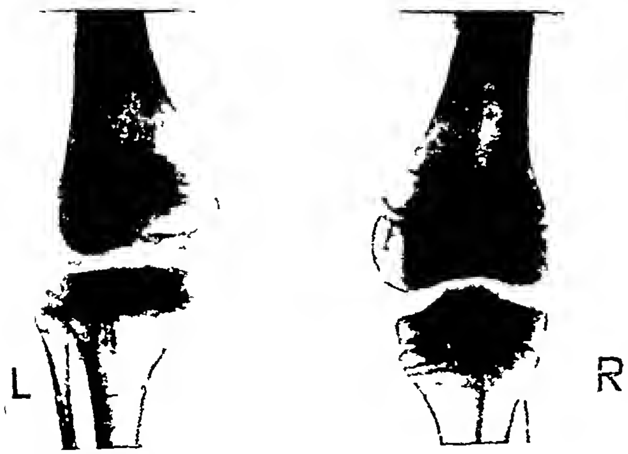

FIG 8A

FIG 8B

Case 19 One year later (Fig 8A) there is evidence of 'Bowing' and late fusion of the upper tibial epiphysis Seven years later (Fig 8B) is seen the typical result of premature fusion at the common site in the tibia There is little or no interference with growth in the tibia

DISCUSSION

In this series of ninety-one tuberculous hip joints there were twenty-nine cases of premature epiphysial fusion at the knee Reports from the United States of America include a series of one hundred and fifty tuberculous hip joints with ten premature fusions (Gill 1947), and ninety-two tuberculous hip joints with nine premature fusions (Ross 1948) From the series we have studied it would appear that the complication has occurred much less frequently in the United States than in this country, which may perhaps be due to the trend in contemporary American practice towards earlier operative interference by which to shorten the duration of treatment (McCarroll and Heath 1947, Pease 1947)

The bulge type of fusion, which occurs so often in the upper end of the tibia, is clearly due to rupture of the thinned cartilage plate, consequent upon local resorption of its cancellous support, as suggested by Gill (1944) The central fragmentary type, seen only in the femur, can be explained similarly, the only difference from the tibial bulge is that a more widely unsupported area of cartilage is subjected to resorption on both aspects In the small number of fragmentary types, confined to the antero-lateral regions of the plates, constant compression appears to be the etiological factor because such fusions were not caused by resorption of cancellous support, and no corresponding involvement of the medial halves was observed

TABLE III

TYPE AND SEVERITY OF HIP DISEASE AND ITS RELATIONSHIP TO PREMATURE EPIPHYSIAL FUSION

	91 hips in the series		64 cases of more than 2 years' duration		29 cases of premature epiphysial fusion	
Typical	(57)	63%	(43)	67%	(23)	79%
Low grade	(22)	24%	(15)	23%	(4)	13%
Extra-articular	(4)	4%	(3)	5%	(1)	3%
Synovial	(8)	9%	(3)	5%	(1)	3%
Abscess	(13)	14%	(13)	20%	(6)	20%
Abscess and sinus	(22)	24%	(18)	28%	(11)	38%

Ross (1948) has shown that early disparity in the circumferential size of the bones of the two lower limbs is due to suppression of osteogenesis on the diseased side The probable cause of this suppression is a permeation of toxins from the infection at the hip The possibility that it is a reflex phenomenon, as suggested by John Hunter (1776) and elaborated by Vulpian (1866), cannot be dismissed, but the hypothesis of Kestler (1947), and the suggestion that there is tuberculous infiltration of the bones, are both untenable Resorption, however, was a constant feature in both limbs, although always more advanced on the diseased side Associated with it, changes in the cellular marrow lead to increased fluidity of the marrow contents—the " adipose osteoporosis " described by Cornil and Ranvier (1887) The more prolonged, the more continuous, and the more efficient the immobilisation, the greater were the changes produced In one case, in which both lower limbs were immobilised continuously for five years, there was premature fusion of both tibial and femoral epiphyses in the affected limb and also of the tibial epiphysis of the normal limb (Fig 9)

The effect of immobilisation in causing soft tissue atrophy has long been known The pathology was discussed fully by Brackett (1891), who showed that patients with hip disease in whom movement had been permitted developed atrophy of the thigh-volume amounting to 1 per cent , and of the leg-volume to less than 1 per cent , whereas patients treated by complete and rigid fixation developed atrophy of no less than 37 per cent in the thigh, and

17 per cent in the leg Bone, when immobilised for long periods and deprived of physiological stimuli, reacts in the same way as the softer tissues—a reaction which conforms with the laws of Wolff (1892) The more advanced resorptive changes occurring at the knee on the diseased side are caused by a combination of toxaemia and immobilisation

The fundamental factors responsible for the bone changes causing premature epiphysial fusion are toxaemia from the infection at the hip, prolonged immobilisation, and the duration of action of either of these factors It must be emphasized that no matter how severe the infection at the hip, premature fusion was never observed during the first two years of the disease

FIG 9A

FIG 9B

Case 17 Patient with disease of the right hip joint in whom both lower limbs had been immobilised for five years There is premature fusion of both lower femoral and upper tibial epiphyses on the right side and of the upper tibial epiphysis on the left Fusion took place between the ages of thirteen and sixteen years

It is clear that injury, in quiescent disease, plays little or no part in the etiology of premature epiphysial fusion Fusion occurred in seven early cases while the limbs were still immobilised, and before weight-bearing had begun Of the five cases of premature fusion in which a pathological fracture occurred during early weight-bearing, four showed clear evidence that fusion had begun even before the fracture was sustained (Fig 7), and in the fifth there was no immediate change in the epiphysial lines, or in the rate of fusion as compared with cases in which there had been no injury The injury of operative intervention might at first appear to have increased the incidence of epiphysial fusion, because the complication occurred in ten of fourteen cases treated by extra-articular arthrodesis, and in five of six cases treated by late corrective osteotomy But in all these cases it was clearly established that the onset preceded the operation The time of onset of fusion corresponds with the later active phase of the disease The only examples of premature fusion in which the factor of injury could not be excluded were those with adduction deformity of the hip joint treated by prolonged traction, especially when there was also knock-knee deformity It was in these cases that premature fusion was limited to the lateral regions of one or other epiphysial plates

The fact that in this considerable series of cases of premature fusion of the upper tibial and lower femoral epiphysis there has been no single example of premature fusion of the upper

fibular epiphysis, and that no such fusion has been reported in the literature, is remarkable. It is unimportant that the fibula is not a weight-bearing bone, because, as we have seen, the complication occurs in the tibia and femur when there has been no weight-bearing. The immunity may perhaps be due to late appearance of the ossific nucleus of the fibular head, retarded still further by disease at the hip, or to the fact that the surface area of the epiphysial plate is so small, and the shaft so slender, that such loss of trabecular support as does occur is insufficient to weaken this area of cartilage to the point of rupture.

CONCLUSIONS

1 In tuberculous disease of the hip, premature epiphysial fusion at the knee joint is due to rupture of the epiphysial cartilaginous plates consequent upon resorption of cancellous support and suppression of osteogenesis.

2 In the tibia, premature fusion is usually preceded by near-central "bulging" of the metaphysial and tibial marrow through the epiphysial plate. In the femur, epiphysial changes preceding fusion are of a fragmentary type.

3 Injury, in quiescent disease, plays little or no part in the causation of premature epiphysial fusion.

4 The factors which are responsible for these changes—local toxaemia and prolonged immobilisation—must exist for not less than two years.

5 In cases which are treated conservatively for long periods the incidence of premature fusion, with serious shortening of the limb, is so high that the wisdom of such treatment must be reconsidered.

We express our sincere thanks to Dr J. Dobson, Dr J. K. Cameron and Dr J. Crosbie who accorded us all the facilities of their hospitals, and gave us much help and encouragement. We would also express our gratitude to the orthopaedic surgeons of Liverpool who gave access to their cases so willingly, and to the radiographers, ward sisters and nurses to whom our visits meant so much extra work.

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RETROSTERNAL DISLOCATION OF THE CLAVICLE

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Dislocation of the clavicle, either at the acromial or sternal end, is much less common than fracture, and retrosternal dislocation is so unusual that there is little reference to it in the literature Standard text-books on fractures and dislocations ignore the condition completely, or dismiss it in a few lines The rarity of the injury, the typical signs and symptoms, and the grave potentialities, have prompted presentation of this case

A youth, seventeen years of age, was admitted to the Toronto General Hospital on March 18, 1948 Four days before admission he was scuffling with a group of boys and fell to the ground As he lay on his left side, supporting his weight on the left shoulder, another boy fell on his right shoulder He felt a painful buckling sensation at the inner end of the left clavicle The limb was immobilised in a figure-of-eight bandage During the next three days he complained of severe pain in the region of the sterno-clavicular joint, a tight feeling in his throat, and difficulty in swallowing His mother noted that, for the first time in his life, he snored when asleep Physical examination showed discolouration of skin over the clavicle with generalised swelling There was difficulty in palpating the sternal end of the bone which is usually so prominent Attempted abduction of the limb, whether active or passive, gave rise to severe pain in the region of the sterno-clavicular joint Radiographic examination confirmed the clinical diagnosis of retrosternal dislocation (Fig 1)

The next day, at operation, a transverse incision was made over the medial end of the clavicle, crossing the sterno-clavicular joint Part of the clavicular head of the left sterno-mastoid was divided There was disruption of the joint, haemorrhage into surrounding tissues, and tearing of the capsule The articular disc was still attached to the sternal part of the joint Even under direct vision it was not possible to reduce the dislocation by pulling on the abducted limb The clavicle was therefore grasped with bone forceps and lifted forcibly from beneath the sternum into its normal position A Compere wire was introduced into the bone at the junction of the inner and middle thirds, threaded across the sterno-clavicular joint into the manubrium sterni, and left protruding at the lateral extremity of the incision Repair was reinforced by fascial sutures passed through drill-holes in the sternum and clavicle as described by Bankart (1938) The limb was immobilised in a plaster spica for two months, after which time the wire was removed

Discussion—The inner end of the clavicle is attached firmly by strong ligaments to the sternum and first rib The capsule, strong in its anterior and posterior distribution, is relatively thin in the superior and inferior areas The oblique plane of the joint almost invites dislocation, and it is the strength of the costo-clavicular ligament, anchoring the clavicle to the first rib, which protects it This ligament must necessarily be torn in dislocation of the joint

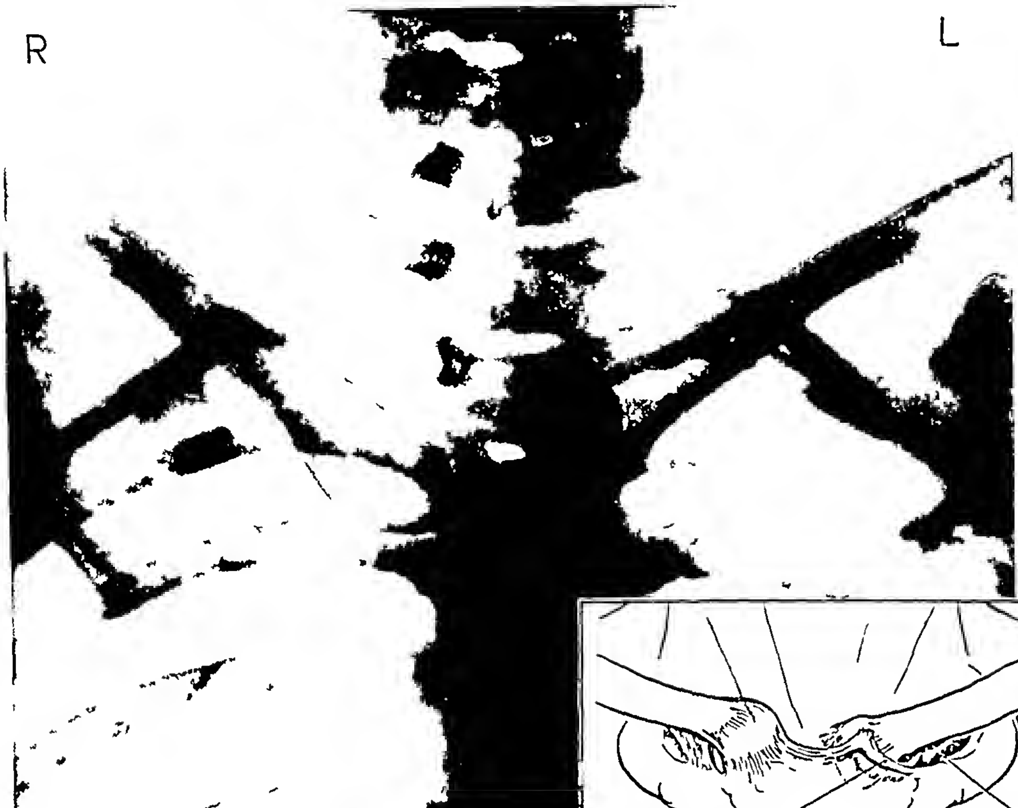
Retrosternal dislocation may occur from direct or indirect violence Examples of both types of injury have been recorded In one case the patient was kicked by a mule In another the injury was a blow on the lateral aspect of the shoulder (Greenlee 1944) In the case now reported the injury was due to indirect violence

In establishing the diagnosis the history is often of assistance, particularly when, after direct or indirect injury to the sterno-clavicular joint, there is local pain and tenderness, limitation of abduction of the limb, dysphagia, snoring due to tracheal pressure, and evidence on physical examination of loss of the normal prominence of the medial end of the clavicle The diagnosis is confirmed by radiographic examination which should include oblique projections, stereograms, and laminograms

The potentialities of this dislocation are so great that the rarity of the injury is indeed fortunate Death has been recorded from tracheal laceration There is also danger of injury

to the great vessels of the superior mediastinum with haemothorax—a complication which caused the death of a Canadian Army dispatch rider at Nijmegan in 1944 (Dewar, F P, personal communication) The oesophagus and thoracic duct might also be involved

Manipulative reduction by traction on the abducted limbs is seldom successful In the case now reported it was impossible to reduce the dislocation by traction even when the parts were exposed at operation Moreover, in the few cases in which closed reduction has been successful, there has usually been redisplacement The degree of damage to joint capsule



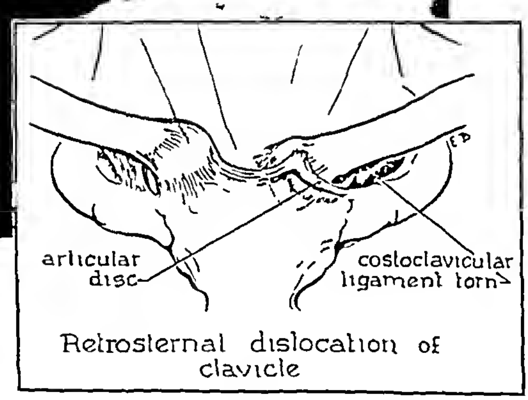


FIG 1

Radiograph taken on admission might at first sight appear to show no abnormality, but more close scrutiny reveals that the left clavicle is riding at a higher and more medial position than the right The inset shows diagrammatically the findings at operation, and emphasizes the joint disruption

and extra-articular ligaments is such that reconstructive surgery is usually indicated Sometimes the sternal end of the clavicle has been removed In other cases it has been fused to the sternum In this case, fascial repair with internal fixation was successful

Summary—Retrosternal dislocation of the clavicle is an unusual injury Serious complications may arise from damage to the trachea, the great vessels of the mediastinum, the oesophagus, and the thoracic duct Operative reduction and reconstruction of the ligaments is the most reliable treatment

Acknowledgment is made to Dr R I Harris Associate Professor of Surgery in the University of Toronto and Chief of the Division of Orthopaedic Surgery of the Toronto General Hospital for his helpful criticism

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FRACTURES OF THE PATELLA

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The subject of fracture of the patella is one in which new interest has arisen during the last ten years because there has been much discussion as to whether or not good function of the knee joint is regained after excision of the bone. One school of thought, led by Brooke (1937) and supported by Watson-Jones (1945) and others, contends that excision of the patella leads to no appreciable weakening and gives a strong joint which is free from symptoms. Such protagonists pursue their belief to its logical conclusion by recommending removal of the patella for many types of fracture. The other school, which is more conservative and of which there are many supporters, believes that complete and accurate reconstruction of the patella after injury is likely to give a joint which will work as well as, and wear better than, one in which the normal anatomy has been disturbed by removal of a component part. The only way to settle this problem is by study of a long-term review of many cases, treated by various methods. In this series, 196 fractures of the patella were reviewed from one to five years after treatment. The patients had been treated in the orthopaedic service of the Royal Air Force, some from the beginning, and others only after initial treatment had been carried out elsewhere. The fact that a group of surgeons took part in treatment should enhance the value of the analysis by averaging such factors as judgment and technical skill.

The results have been examined after study of all information available from detailed R.A.F. clinical records and other Service sources, and from questionnaires which have been sent out. Having regard to the fact that the patients represented many nations, all over the world, the response has been good. The aim was to obtain a subjective view, and care was taken to make it clear that the investigation was in no way related to Service or Ministry of Pensions requirements.

It is of course obvious that not all fractures of the patella need operation. Many marginal and polar fractures, without separation, in which the articular cartilage is undamaged and the extension mechanism is intact—a group which accounted for 15 per cent. of the cases in this series—require no more than a brief period of protection. Indeed it would be wise to classify simple fractures of the patella not in relation to the anatomical type, but in relation to the degree of injury to articular cartilage and the damage to the quadriceps expansion. For example, a stellate fracture without displacement which is due to direct violence must almost certainly be associated with considerable injury to the articular cartilage of both patella and femur; whereas a transverse fracture without displacement which is due to indirect violence may be associated with little or no damage to the articular surfaces. Many surgeons would adopt the same treatment for both these groups of fracture, but clearly without good reason.

The treatment adopted in this series of 196 fractures was: excision of the whole bone, 101; excision of part of the bone, 33; open reduction and suture, 18; suture with later excision, 14; no operation, 30. These procedures have been investigated in relation to the type of fracture (Table I). Some fractures of the upper and lower thirds were transverse, but the majority were comminuted. Fractures in which the articular surface did not appear to be involved are described as "polar fractures." Thirty-seven were open fractures, twenty-five being treated by excision of the whole bone, six by excision of one fragment, one by suture and fixation, and five by no operation.

ANALYSIS OF IMMEDIATE TREATMENT AND RESULTS

Since we are concerned primarily with the principles of treatment, all cases in which the result was influenced by unexpected complications have, so far as possible, been excluded Such complications will be considered separately

Excision for closed fractures—These cases have been divided into those operated upon during the first fourteen days, and those operated on later In the first group the average period of post-operative immobilisation was just under four weeks The average period of disability was four months, after which time all but one had full extension movement, and flexion movement to 90 degrees two had full movement In the second group, which were operated on later, the average post-operative immobilisation was four weeks, and the average total disability nearly six months It would appear, therefore, after excluding the average pre-operative time, that patients operated on within the first fourteen days required one month less for recovery than those operated on after a longer interval

TABLE I

Analysis of 196 Fractures of the Patella

Type of Fracture in relation to Operation performed

(Type not stated in 24 Cases)

	Comminuted fracture	Fracture upper part	Fracture lower part	Transverse fracture	Vertical fracture	Polar fracture
Excision of bone	46	5	26	13	1	0
Excision one fragment	1	6	14	0	7	5
Suture and fixation	0	1	11	6	0	0
No operation	3	2	3	4	5	13
	50	14	54	23	13	18

Excision for open fractures—A similar division was made into two groups In all but two cases which were operated upon during the first fourteen days the excision was part of primary wound treatment In these, the average period of post-operative immobilisation was three weeks, and the average disability period nearly five months Eight regained full extension movement and 90 degrees or more of flexion movement, four had full movement In the second group of compound fractures of the patella, where the bone was excised later than fourteen days, the average period elapsing between injury and excision was fourteen weeks The average duration of post-operative immobilisation was five weeks, and the average total disability was eight and a half months If the pre-operative loss of time is subtracted it leaves a disability time of just over five months In this group, all regained full extension movement and 90 degrees or more of flexion movement, one had full movement

Excision of one fragment—Analysis of patients in whom one fragment was excised showed that the average disability period was nearly four months All but one regained 90 degrees of flexion movement, and four out of seventeen had full movement Those operated on after fourteen days showed a closely comparable period of post-operative disability (3 7 months as compared with 3 6 months), one had less than 90 degrees flexion movement and four out of ten had full movement

Suture—Nearly all fractures treated by operative reduction and internal fixation, most of them transverse fractures, were operated on within the first fourteen days The average period of post-operative immobilisation was six and a half weeks, and the average post-operative disability period five months All regained full extension movement, and in all

but one there was 90 degrees or more of flexion movement, six out of fourteen regained full movement Table II summarises the analysis of post-operative periods of disability and immediate results

If all patients in the series are grouped together it will be seen that, of those treated by operation, twenty-one regained full knee movement after an average period of immobilisation of 3 3 weeks and an average disability period of 14 3 weeks, as compared with the average immobilisation period in all groups of 4 4 weeks and the average disability period of 17 weeks This gives a rough but fairly comprehensive picture of what can be expected from fractures of the patella treated on orthodox lines, assuming that there is no unforeseen complication of treatment

TABLE II

ANALYSIS OF 118 FRACTURES OF THE PATELLA IN WHICH THERE WAS NO UNEXPECTED COMPLICATION OF TREATMENT

	Number of cases	Average time of immobilisation	Average time of disability (post-op)	Range of movement	
		Weeks	Months		
Excision of closed fractures—					
Before 14 days	16	3 75	4 0	More than 90° flexion Full movement	15 2
After 14 days	12	4 0	5 0	More than 90° flexion Full movement	11 0
Excision of open fractures—					
Before 14 days	10	3 1	4 8	More than 90° flexion Full movement	8 4
After 14 days (Average 14 weeks)	9	5 0	5 3	More than 90° flexion Full movement	9 1
Excision of one fragment—					
Before 14 days	17	3 8	3 6	More than 90° flexion Full movement	16 4
After 14 days	10	4 5	3 7	More than 90° flexion Full movement	9 4
Suture of fragments	14	6 5	5 0	More than 90° flexion Full movement	13 6
No operation	30	4 5	2 2	More than 90° flexion Full movement	30 26

In considering these figures it should be remembered that they are averages and therefore subject to variation Nevertheless I am advised that statistically the variation of disability between patients operated on before and after fourteen days appears to be significant

COMPLICATIONS DIRECTLY CONNECTED WITH TREATMENT

Complications directly associated with treatment included wound infection, peroneal palsy, thrombo-phlebitis, aseptic necrosis, refracture, and malunion A certain number of cases have been excluded from this analysis by reason of other injuries such as fracture of the shaft of the femur of the same limb, fracture of the leg bones, extensive wounds or burns, which necessarily modified the treatment

Wound infection—In the series of nearly two hundred operations, performed by many surgeons, there were nine cases of wound infection In two, the infection was sufficient to cause ankylosis of the joint, one being a compound fracture treated by early excision of the wound and of the patella In the other seven cases, infection outside the joint accounted only for delay in healing and slow recovery of function

Peroneal palsy—Two patients suffered temporary peroneal palsy

Thrombo-phlebitis—One patient developed severe thrombo-phlebitis with pulmonary embolism, and after eight months he had a swollen shiny leg with a range of movement from 180 to 120 degrees

Aseptic necrosis—Two patients in whom the fracture was fixed by a vitallium screw developed aseptic necrosis of the proximal fragment One of these was treated by excision of the patella and repair of the quadriceps expansion

Refracture and malunion—Two patients sustained refracture without displacement The group of fourteen cases in which suture was followed by excision all showed early or late complications of suture Four patellae were excised for refracture, from six weeks to twelve months after suture, five were excised for malunion with patello-femoral osteoarthritis, from seven months to six years after suture, two were excised early after bad reduction and wiring, one was excised for vascular changes after screwing, and in two, the reason was not stated

RESULTS AS ESTIMATED BY THE PATIENTS

The form of questionnaire, with analysis of the replies, is shown in Table III The proportion of answers received was highest among those patients whose patellae had been excised—amounting to three-quarters of the total, it was lowest among those in whom no operation had been performed The figures have been reduced to percentages for ease of comparison Due caution must of course be exercised in comparing proportions of ninety-three patients treated by total or partial excision of the bone, with proportions of only twelve patients treated by open reduction, and eleven patients treated without operation Indeed, with totals so small, the last two groups represent the least significant part of the inquiry The figures from which definite conclusions can be drawn are the proportions of ninety-three patients who still complained of aching, pain, "giving way," and wasting, two years or more after excision of part or all the bone Of seventy-one patients treated by total excision of the patella, thirty-five were reviewed more than three years, twenty more than four years, and sixteen more than five years after operation So far as could be judged there was no evidence of improvement or deterioration between the second and the fifth years The conclusion must be accepted, therefore, that after excision of the whole patella, or part of the patella, a high proportion of patients complain of persistent aching and discomfort, and many have quite serious disability as represented by difficulty in running, working on ladders, and working in confined spaces It is interesting to note that the number of patients who complained of "giving way" is almost exactly the same as the number who reported that there was wasting of the thigh In most patients who replied to the questions, the range of movement was good although many failed to achieve the terminal degrees of flexion movement

DISCUSSION

In this study it is the analysis of replies to the questionnaire which calls for emphasis The immediate results are important, but if these are reasonably satisfactory—and Table II shows that they are—it is the long-term results in which we are most interested When it is proposed to remove a fractured patella in a fit young man, it is well to know with some certainty how much disability is likely to remain Table III gives a clear measure of this, and it needs no elaboration It is evident that in most patients the disability is considerable The findings do not bear out some claims which have been made in the past This does not mean that the patella should never be excised, but it does mean that it should be excised only after careful deliberation

In vertical or marginal fractures, all fractures without displacement, and polar fractures where the extensor mechanism is intact, no operative intervention is indicated At the other extreme, only one treatment is indicated for fractures in which the whole bone is comminuted and the fragments are separated, and that is excision of the fragments with

suture of the extensor apparatus Other varieties, lying between these extremes, call for much more thought In eccentric fractures, whether transverse or comminuted, where more than half the bone and articular cartilage is intact, the small fragments should be removed and the quadriceps expansion or patellar tendon fixed to the main fragment In central transverse fractures, open reduction and internal fixation is probably the best treatment, but only if reduction is accurate and fixation adequate Unless it is possible to secure and to maintain anatomical reduction, excision is probably the better treatment In open fractures the same principles apply, bearing in mind the primary importance of treatment of the wound

TABLE III

REPLIES RECEIVED FROM 116 PATIENTS TO FOLLOW-UP QUESTIONNAIRE

All figures are percentages	Excision (71 cases)		Partial excision (22 cases)		Reduction and fixation (12 cases)		No operation (11 cases)	
	Yes	No	Yes	No	Yes	No	Yes	No
Is the knee normal?	5	95	45	55	25	75	36	64
Does it ache?	90	10	50	50	67	33	45	55
Does it pain?	79	21	38	62	64	36	36	64
Does it get stiff?	76	24	50	50	50	50	27	73
Does it swell?	24	76	13	87	16	84	9	91
Does it give way?	60	40	18	82	42	58	9	91
Can you fully straighten?	84	16	100	0	92	8	100	0
Is it straight on standing?	98	2	100	0	92	8	100	0
How near is heel to buttock?	0"–6" = 16 6"–12" = 42 12"–18" = 34 18"+ = 8		0"–6" = 36 6"–12" = 50 12"–18" = 10 18"+ = 4		0"–6" = 50 6"–12" = 0 12"–18" = 50 18"+ = 0		0"–6" = 80 6"–12" = 20 12"–18" = 0 18"+ = 0	
Is it wasted?	60	40	36	64	50	50	9	91
Can you walk upstairs normally?	61	39	81	19	58	42	82	18
Can you walk downstairs normally?	45	55	66	34	33	66	82	18
Can you stand on one leg?	90	10	100	0	66	33	100	0
How far walk without discomfort?	¼ mile = 24 ¼–2 miles = 39 2–4 miles = 13 4 miles+ = 24		¼ mile = 4 ¼–2 miles = 8 2–4 miles = 8 4 miles+ = 80		¼ mile = 33 ¼–2 miles = 25 2–4 miles = 9 4 miles+ = 33		¼ mile = 9 ¼–2 miles = 19 2–4 miles = 9 4 miles+ = 63	
Can you run?	50	50	77	23	33	66	91	9
Can you play games?	Some 44	None 56	Some 52	None 48	Some 25	None 75	Some 73	None 27
Change of job?	Yes 41	No 59	Yes 9	No 91	Yes 55	No 45	Yes 0	No 100

The second problem, solution of which may be assisted by the results of this investigation, is that of the best post-operative treatment Analysis of these cases, treated by many surgeons, showed clearly that there was lack of agreement In the Royal Air Force orthopaedic centres, post-operative immobilisation after excision varied from three to seven weeks In cases in which the primary treatment had been carried out elsewhere the period varied from a few days in a bandage to three months in plaster This is an important point,

because if the period is too long there is much stiffness of the joint and protracted invalidity, whereas if it is too short, stretching or rupture of the tendon may make it necessary to perform another operation for secondary repair or shortening of the tendon Review of these cases suggests that the best duration of post-operative immobilisation is from three to four weeks, during which time the patient should practise static quadriceps contraction, and may be allowed weight-bearing after the tenth day

SUMMARY

1 A series of 196 fractures of the patella has been reviewed

2 The treatment adopted was excision of the whole bone—101, excision of part of the bone—33, open reduction and suture—18, suture with later excision—14, no operation—30

3 The average time of post-operative disability varied from 3 6 to 5 3 months The time was appreciably less when operation was carried out before the fourteenth day than when it was done later

4 An attempt was made to follow up, two to five years after injury, those patients in whom the result was not influenced by other major injuries of the limbs or by unexpected complications Replies to questionnaires were received from 116 patients

5 Of these, all regained a good range of movement, varying from 90 degrees of flexion to full movement, whether treatment was by excision of part or all the bone, or by open reduction and suture

6 The late results of excision of the patella, as estimated by the patients themselves two to five years after treatment, showed that there was considerable residual disability

7 After total excision of the bone only 5 per cent of patients considered that the knee was normal, 90 per cent complained of aching, 60 per cent complained of "giving way" After excision of one fragment, about half the patients regarded the knee as normal and half complained of aching and stiffness

8 The number of fractures in this series treated by accurate internal fixation was too small to make justifiable comparisons

9 The indications for non-operative treatment, open reduction and accurate internal fixation, excision of one fragment, and excision of the whole bone are discussed

10 Excision of part or all the patella is often inevitable, but some claims made in the past for the results of this operation are not substantiated

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Editor's comment—It is fair to say that this stimulating and provocative contribution has been published only after much discussion and some disagreement Every article which is published in the Journal of Bone and Joint Surgery is subjected to close scrutiny and severe criticism and this article has received its full share The divergent views of members of the Editorial Board may perhaps best be summarised in relation to the sixth paragraph of the Summary, in which it is stated that 'the late results of excision of the patella showed that there was considerable disability ' The question that arises is whether such disability was attributable to excision of the bone or whether it was the inevitable consequence of the original injury Are we sure that after such injury the residual disability would have been less if the patella had been sutured and not excised?

ARTERIAL SUPPLY TO THE FEMORAL HEAD AND ITS CLINICAL IMPORTANCE

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Avascular necrosis of the femoral head is most often seen after fracture of the neck of the femur but it may also be due to slipping of the upper femoral epiphysis, reduction of congenital dislocation of the hip joint, and pyogenic or tuberculous infections of the femoral neck it is the pathological basis of Perthes' disease In understanding these problems, accurate knowledge of the arterial supply to the head of the femur is essential The relative literature is voluminous but contradictory, and this study is presented in an attempt to clarify the subject

The precarious state of the circulation in the femoral head has been known for many years Astley Cooper (1822) knew of the blood supply from vessels which passed along the neck, and from small subsidiary vessels in the ligamentum teres In his day, intracapsular fractures invariably failed to unite unless they were impacted He claimed that the principal reason for this failure was the " absence of ossific action in the head of the thigh bone when separated from its cervix, its life then being supported solely by the ligamentum teres" Non-union was the dominant problem and inadequacy of blood supply to the femoral head was important only in so far as it affected union of a fracture Astley Cooper did not distinguish between femoral heads which had some residual blood supply and those which were entirely avascular and necrotic

With improved methods of immobilisation, union is now achieved in the majority of such fractures Eyre-Brook and Pridie *(1941)* reported union in *58 7* per cent of seventy-five fractures, and Boyd and George (1947) reported union in 86 5 per cent of one hundred and forty-one fractures The important remaining cause of non-union is avascular necrosis It is well established, however, that union may take place even when the head of the femur is avascular In these circumstances weight-bearing causes fragmentation of the dead bone, or pathological fracture at the junction of dead and living bone Secondary arthritis is then a frequent complication Carrell and Carrell (1941), Brailsford (1943), Eyre-Brook and Pridie (1941), and Seddon (1936), noted the high incidence of avascular changes after fracture of the femoral neck in children Brailsford reported fifteen such fractures, more than half of which showed avascular changes

Eyre-Brook and Pridie (1941) described the " fracture- shaft angle " and were impressed by the relationship between this angle and the incidence of avascular necrosis Such necrosis developed in 14 7 per cent of their patients, and in every case the fracture-shaft angle was less than 37 degrees Linton (1944) studied 365 intracapsular fractures and presented statistical evidence that fixation with a Smith-Petersen nail increased the incidence of necrosis This method is widely practised and it is important to determine whether or not insertion of such a nail has harmful effects and, if so, whether they can be avoided

HISTORICAL REVIEW

The history of investigations into the arterial supply of the femoral head has been reviewed fully by Chandler and Kreuscher (1932), Nordenson (1938), and Wolcott (1943), and in this paper reference will be made only to some of the more important studies Hyrtl (1846) stated that the vessels of the ligamentum teres were not of nutritional value to the femoral head, but that they spread out upon the surface of the fovea and immediately entered the foveolar veins Langer (1876) showed by injection that vessels did in fact enter the developing

femoral head through the ligamentum teres and that they were of fundamental importance to the ossific centre He claimed that variations existed in the adult but that these were secondary changes in which the vessels of the round ligament shrank to unimportance so that cervical vessels took over an almost exclusive supply of the head Walmsley (1915) examined one hundred round ligaments but never found a vessel of any size, he concluded that arteries of the ligament could convey no more than a trifling amount of blood Furthermore, he demonstrated by injection that these vessels did not supply the ossific centre in two children aged two years and six years Kolodny (1925) investigated a number of foetuses, infants, children, and adults, and concluded that the vessels of the ligamentum teres played a certain role in nutrition of the femoral head in the new-born and in children, but that they were of no importance in the adult Zemansky and Lippmann (1929) came to similar conclusions Chandler and Kreuscher (1932) examined one hundred and fourteen round ligaments, and made serial sections of six femoral heads, including two in which there had been fractures of the femoral neck The subjects were adults, averaging forty-eight years The ligament was absent in only one case and all others contained vessels In four, the vessels were of pre-capillary size, but the others carried a significant blood supply In six specimens, serial sections were made of the femoral head and the round ligament, and it was established that there was anastomosis between the arteries of the ligament and those within the head These observations are significant and they show that, even in the adult hip, the ligamentum teres is a vascular structure Nordenson (1938) examined one hundred and twenty-nine normal round ligaments He found that vessels were present in the ligament at all ages, but that with advancing age there was increasing obliteration by arteriosclerosis Strangely, however, he found that in medial fractures of the femoral neck the foveolar vessels were always large He suggested that these vessels, even although arteriosclerotic, were capable of hypertrophy, and that this capacity might explain why necrosis of the head was not more common

Wolcott (1943) investigated the arterial pattern at various ages up to adolescence He had previously made similar investigations in adults His conclusions are important 1) In infants and children the ossifying centre in the developing head of the femur receives its blood supply from capsular vessels which arise from the medial circumflex artery 2) The ligamentum teres vessels do not enter the head of the femur in children, nor do they contribute to the nourishment of the growing femoral head, except for very small vessels at the site of implantation of the ligament into the foveolar area 3) Anastomosis between vessels of the ligamentum teres, capsular arteries, and nutrient arteries of the shaft, does not take place until ossification of the femoral head is almost complete, by which time the vessels of the three systems unite by penetrating the thinned area of cartilage at the fovea 4) The ligamentum teres circulation is closed, so far as the femoral head is concerned, until such anastomosis takes place

In describing the arrangement present in the adult, Wolcott made these observations 1) In approximately 80 per cent of specimens which were injected successfully, even in patients of advanced age, the ligamentum teres carried at least one main artery which penetrated the head of the femur, and anastomosed with vessels entering by way of the capsule 2) In approximately 20 per cent of adult specimens in which arteries of the ligamentum teres were injected successfully, the vessels failed to enter the femoral head In these instances opaque material could be seen to course through the arteries to the foveolar area from whence it was returned through the veins of the ligament

So far as I know, Wolcott was the first investigator to state that the foveolar vessels increased in size with age This contrasts with other observations, but it is compatible with observed clinical facts Schmorl (1924), Hesse (1925), and Santos (1930) presented cases in which the proximal fragment of the head was found alive with only vessels of the ligamentum teres remaining intact

METHODS OF INVESTIGATION

This study is based on the examination of forty-four femora obtained from fresh cadavers, the ages varying from birth to seventy-seven years The vessels were injected with barium sulphate, and examined by X-ray after decalcification of the femoral head The specimens were cleared by Spalteholz' method which makes the cartilage, fibrous tissue, decalcified bone, and fatty marrow transparent, while the red marrow and vessels containing red cells or barium sulphate remain opaque Transverse sections were made of thirty round ligaments, close to their femoral attachments Transverse sections were also made just distal to the articular cartilage of the femoral head in order to confirm the success of the injection, and to corroborate the findings regarding distribution of the vessels about the periphery of the neck The size of the vessels was assessed by means of an ocular micrometer An effort was made to measure the lumen of the vessels at their point of entry into the epiphysis, or at an equivalent position in the adult

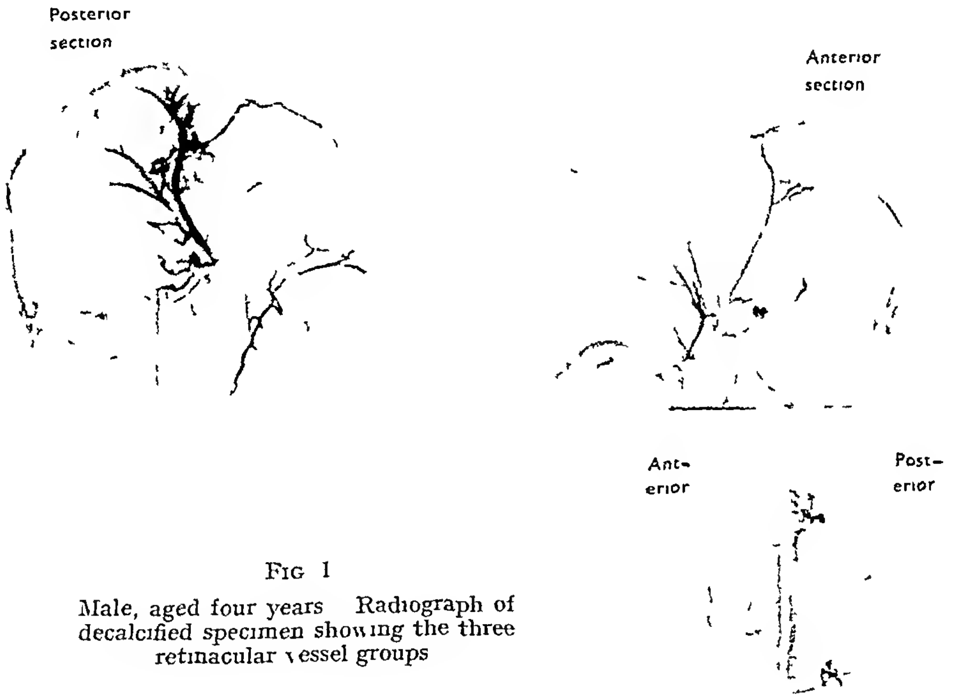

FIG 1

Male, aged four years Radiograph of decalcified specimen showing the three retinacular vessel groups

RESULTS OF THE INVESTIGATION

Three groups of vessels supply the upper end of the femur, namely the nutrient artery of the shaft, the retinacular or capsular arteries, and the foveolar artery or artery of the ligamentum teres The term " capsular " is in common use and is quite accurate, but the term " retinacular " stresses the relationship which these vessels have to the retinacular fibres and the periphery of the neck It also corrects the erroneous view that these vessels run in the substance of the external fibrous capsule and that division of the capsule necessarily impairs the circulation of the femoral head The term " foveolar," in place of " artery of the ligamentum teres," is adopted simply for brevity

Nutrient artery—The nutrient artery enters the mid-shaft of the femur and may be single or double. The superior branch runs upwards in the medullary cavity and anastomoses with cervical branches of the retinacular arteries. In no specimen from a patient of less than thirteen years of age could I demonstrate nutrient vessels crossing the epiphysial plate from the metaphysis to the epiphysis. However, such an anastomosis could be demonstrated across this zone in several adult specimens. It is not possible to say how frequently this occurs, because the presence of red marrow, or of a dense cloud of capillaries, made visibility poor in some specimens. The anastomosis occurred between vessels of 0.1 to 0.25 millimetres in diameter. It may be supplemented by the inosculation of fine capillary tufts, which appear to belong to both nutrient and retinacular arteries.

Retinacular arteries—These vessels arise from the medial and lateral femoral circumflex arteries. There is, however, a brisk extracapsular anastomosis in the region of the trochanteric fossa to which the inferior gluteal, profunda femoris, obturator, and circumflex

FIG. 2

Female aged four years. Radiograph of specimen showing only postero-superior and postero-inferior vessels.

arteries contribute. The circumflex arteries lie superficial to the distal part of the fibrous capsule and they do not run within its substance; branches of the arteries pierce the fibrous capsule near its lateral extremity and run medially along the neck of the femur, deep to the reflected cuff of synovial membrane. It is in this position that the vessels are associated with retinacular fibres. As a rule they are found in groups, although occasionally a few isolated and separate vessels may be observed.

There are three main groups of retinacular arteries—postero-superior, postero-inferior, and anterior. The first two groups are branches of the medial femoral circumflex artery and they run along the upper and lower borders of the neck of the femur. If one looks at the head and neck of the right femur from the medial aspect (as in Figs. 1 and 2 insets) the postero-superior vessels are found between eleven and two o'clock, and the postero-inferior vessels between five and seven o'clock. Although the groups may extend on to the front of the

neck, they are usually posterior These two groups are moderately large and quite consistent, the postero-superior group being usually the larger, and occasionally providing the sole supply to the epiphysis The anterior group is the smallest and least constant, its vessels are branches of the lateral femoral circumflex artery (Figs 1 and 2) The relative frequency of the groups, and estimations of their sizes, are shown in Tables I to III

TABLE I

POSTERO-SUPERIOR RETINACULAR ARTERY

Age	Number of specimens	Postero superior vessels present	Range of size of vessels	Mean size
Children	24	24 (100 per cent)	0 125–1 875 mm	0 730 mm
Adults	20	20 (100 per cent)	0 300–1 550 mm	0 839 mm

TABLE II

POSTERO-INFERIOR RETINACULAR ARTERY

Age	Number of specimens	Postero-inferior vessels present	Range of size of vessels	Mean size
Children	24	23 (95 per cent)	0 150–0 875 mm	0 467 mm
Adults	20	16 (80 per cent)	0 150–0 625 mm	0 410 mm

TABLE III

ANTERIOR RETINACULAR ARTERY

Age	Number of specimens	Anterior vessels present	Range of size of vessels	Mean size
Children	24	16 (65 per cent)	0 025–0 525 mm	0 184 mm
Adults	20	5 (25 per cent)	0 100–0 300 mm	0 250 mm

TABLE IV

FOVEOLAR VESSELS

Age	Number of specimens	Number with penetrating vessels	Range of size of vessels	Mean size
Children	24	8 (33 3 per cent)	0 075–0 30 mm	0 183 mm
Adults	20	14 (70 per cent)	0 075–0 625 mm	0 328 mm

The retinacular vessels lie loosely under the synovial membrane, sometimes in mesenteric-like folds of synovial membrane In their cervical course these vessels supply many branches to the femoral neck which anastomose with the nutrient artery of the shaft Branches from the superior vessels are particularly numerous and they run a remarkably straight path from their origin to the base of the femoral neck Despite the attachment of these branches, the mid-cervical parts of the retinacular vessels are quite mobile, in marked contrast to the fixation which may be noted as they approach the articular cartilage

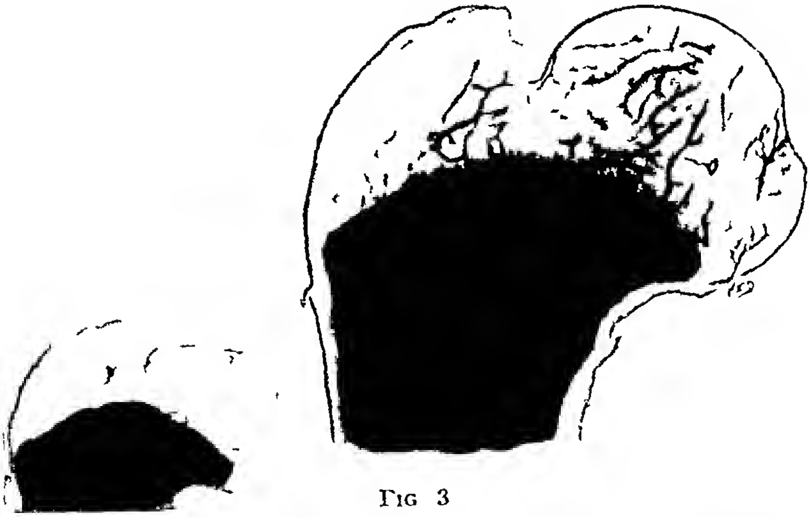

FIG 3

Male aged two months Spalteholz' preparation Ossific centre not present Postero superior and postero inferior retinacular vessels are seen A curved penetrating foveolar vessel is passing up to the cartilaginous head The inset is a photograph of the specimen

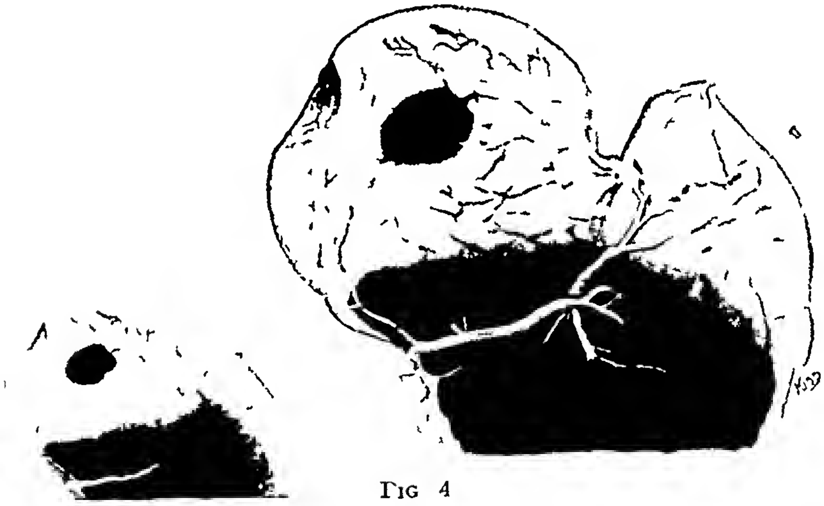

FIG 4

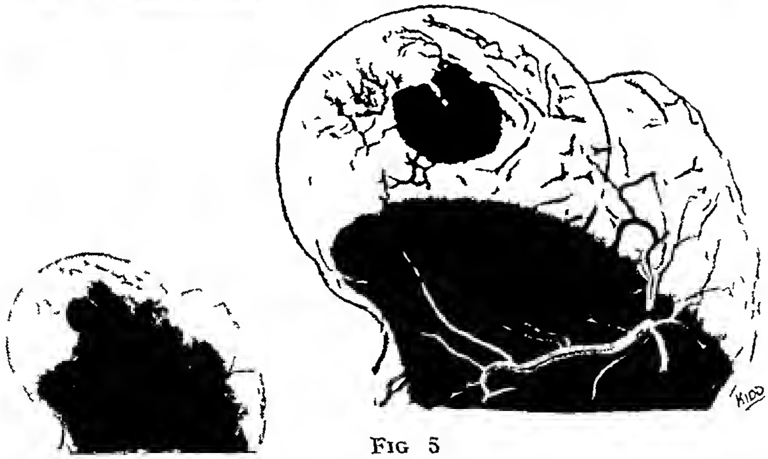

FIG 5

Male aged six months Fig 4 shows posterior view of Spalteholz' preparation Retinacular vessels are supplying the ossific centre and passing beyond it to the subarticular region Foveolar vessels are spread out on the surface of the fovea Three very small vessels pass deep to the surface but do not reach the ossific centre Fig 5 shows the oblique view, the superficial distribution of foveolar vessels can be seen Insets are photographs of the specimens

The postero-superior group of retinacular vessels do not pierce the epiphysial cartilage, they cross the plate at its periphery and then turn towards the centre of the femoral head The postero-inferior and anterior vessels often cut the corner of the plate Within the substance of the head, the retinacular vessels anastomose with each other, and with the nutrient and foveolar arteries if these are present

Foveolar artery—The foveolar artery arises either from the obturator or medial femoral circumflex arteries, or from both It passes into the acetabulum under the transverse ligament and, after giving off a pulvinar branch to the Haversian fat pad, it runs along the ligament to the femoral head The foveolar vessel was present in every ligament examined, but the size varied considerably The important question is whether or not the vessel contributes to the supply of the ossific centre, or to that of the adult head In eight specimens out of twenty-four, in children up to the age of thirteen years, the artery penetrated the fovea and supplied the deep cartilage of the head or the ossific centre The vessels were very small and varied from one to five in number (Figs 7 and 8) The size of these vessels is shown in Table IV In the other sixteen specimens the vessels spread out over the surface of the fovea like the fingers of an outstretched hand, obviously being concerned solely with supply of the fibrous tissue of the ligament and its attachment to the cartilaginous head (Figs 4–6)

FIG 6

Male, aged four years Postero-superior retinacular vessels are well seen Foveolar vessels do not cross the cartilaginous zone between fovea and ossific centre

In adults there was striking alteration in the size and arrangement of the foveolar vessels They penetrated the osseous head in fourteen out of twenty specimens In other specimens visibility was poor, owing to red marrow and perifoveolar capillaries, and accurate observations could not be made It is evident that there is anastomosis in at least 70 per cent of adult cases, and possibly in more than 70 per cent As seen in Table IV, the incidence of penetrating foveolar vessels in adults is approximately double that which is found in children, and the diameter of the vessels is increased by 80 per cent Adult foveolar vessels are illustrated in Figs 7 and 9

DISCUSSION

There is no dispute as to the existence of three main arterial groups supplying the femoral head Difference of opinion exists only on the questions of the relative size and importance of the vessels, and the effect which age may have on foveolar vessels Many diverse views have been expressed Unfortunately some investigators have failed to publish the factual basis of their studies, so that critical analysis of their papers is of little value It is generally agreed that retinacular vessels represent the chief arterial supply to the upper femoral epiphysis and the adult head Discussion is centred upon the relative importance of the foveolar and nutrient arteries Foveolar vessels appear to be of significance in a minority of children, whereas in adults the vessels are of increasing value The nutrient vessels are unimportant so far as the epiphysis of the child is concerned but they constitute a supplementary source of supply in some adults Examination of material from avascular femoral heads has been infrequent Observations on Perthes' disease and other necrotic lesions in

children are very rare and I can find no reference to injection of the arterial system in these conditions We have no alternative, therefore, but to resort to hypothesis in attempting to correlate the pathological findings with known facts about the circulation

Relative importance of the retinacular and foveolar vessels in children—The cartilaginous head and the ossific centre are supplied almost entirely from retinacular vessels, while in a few specimens the foveolar vessels contribute In the series now reported, foveolar

FIG 7

Male aged sixty-four years Posterior half of specimen (Spalteholz' preparation) The perifoveolar cloud of capillaries is visible A penetrating foveolar artery of moderate size is passing toward the postero-superior retinacular artery

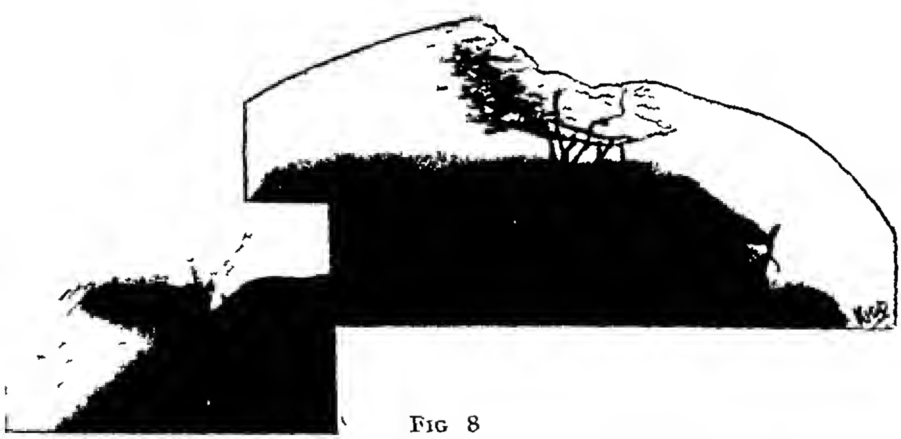

FIG 8

Female, aged six years Foveolar area of specimen (Spalteholz' preparation) Five vessels are seen passing from the fovea into the ossific centre

vessels penetrated the deep cartilage or the ossific centre in only eight cases out of twenty-four Most of the vessels were small, but in view of the size of the femoral epiphysis there was every possibility that they could sustain its life The evidence indicates therefore that the foveolar vessels never constitute the chief vascular supply to the femoral head in children, but that they are of importance in a minority of cases If this view is accepted the site of obstructive vascular lesions causing avascular necrosis must be located in the retinacular group of vessels The foveolar supply may afford additional protection to the ossific centre The epiphysis in the child is more dependent upon retinacular vessels than is the corresponding area of bone in the adult, thus explaining the greater frequency of avascular necrosis in children

Legg-Perthes' disease—Although Jackson Burrows (1941) suggested that venous obstruction might be the cause of Perthes' disease, most investigators believe that arterial obstruction of undetermined nature is the probable cause If injury is the cause of Perthes' disease vulnerability of the epiphysis to infarction will be greatest when the blood supply is derived largely from the postero-superior vessels In other words, multiple sources of vascular supply provide a safeguard to the nutrition of the femoral epiphysis, and in contrast, concentration of the vascular supply to one group of vessels constitutes a potential danger I believe that the postero-superior group of vessels is susceptible to pressure from the acetabular lip and its labrum in positions of forced abduction and external rotation of the hip, and that it is individuals with this pattern of vascular supply who are most prone to Perthes' disease

Congenital dislocation of the hip—Fragmentation of the epiphysis after reduction of congenital dislocation of the hip joint appears to be due to avascular necrosis It is unlikely that the

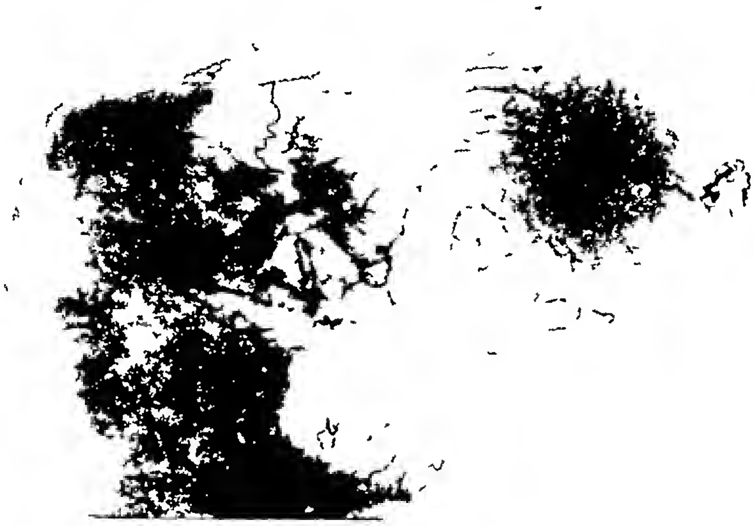

FIG 9

Male aged sixty years Photograph of the posterior half of a decalcified specimen This shows retinacular and nutrient arteries and a good-sized foveolar vessel

changes could be produced by direct trauma, the vessels and the ossific centre lie deeply within the substance of the cartilaginous head and are thus protected from injury Moreover it is difficult to believe that manipulative reduction would cause extensive damage to extra-capsular vessels supplying the hip joint Again, I suggest that the postero-superior vessels are the most likely site of vascular damage Fragmentation has been observed in the *sound* hip after fixation in full abduction and external rotation, but not when this joint has been left free The degree of pressure on the vessels trapped between the femoral neck and acetabular margin depends upon the degree of abduction, the prominence of the posterior acetabular lip, and the tightness of the adductor muscles After manipulative reduction with gentle stretching of the adductor muscles, the femur usually assumes a position of 45 degrees abduction, this may be accepted as a position of safety so far as the retinacular vessels are concerned When the adductors are very tight, it would seem less dangerous to the circulation in the femoral head to lengthen them by tenotomy than to stretch them forcibly, using the postero-superior surface of the femoral neck as a fulcrum

Epiphyseolysis capitis femoris—Avascular necrosis is not a frequent complication of the type of epiphyseolysis which is gradually progressive It does occur, however, in the acute traumatic type, and in cases treated by vigorous manipulative or operative reduction Waldenström (1934) suggested that these changes were due to surgical division or rupture

of vessels in the ligamentum teres It is true that foveolar vessels may represent the main vascular supply remaining to the slipped epiphysis On the other hand, if the retinacular vessels were damaged irreparably in every case of epiphyseolysis, avascular necrosis should occur more frequently There are several anatomical facts which would explain escape from injury of the retinacular vessels when slipping occurs slowly Displacement occurs between the epiphysial cartilage and the metaphysis (Waldenström 1930) at a level where the retinacular vessels are still quite mobile, not yet having reached the vicinity of the epiphysial plate Thus when the epiphysial plate and epiphysis slip downwards and backwards the vessels may escape traction injury, particularly if the slipping is gradual or slight so that they may elongate and accommodate themselves to the new position of the epiphysis But if the slipping is rapid, or extensive, the vessels are more likely to be damaged The postero-inferior group of vessels, which are even more mobile than the postero-superior group, are more likely to be injured by forcible manipulative reduction than by gradual stretching due to progressive displacement of the epiphysis

Relative importance of retinacular and foveolar vessels in adults—In the adult, the united epiphysis receives nourishment from additional sources The retinacular vessels are still predominant, but the nutrient foveolar vessels take over an increasing share In fourteen of the twenty specimens examined, foveolar vessels penetrated the femoral head and supplied it with a significant amount of blood, thus confirming Wolcott's observations The foveolar supply is, however, variable sometimes there is none, but in the majority of cases it is present to a variable extent

Fracture of the neck of the femur—In fractures of the neck of the femur, the fate of the head depends upon the residual vascularity, which is decided at the moment of maximal displacement of the bone It is obvious that all intra-osseous vessels in the neck are disrupted and that blood supply depends wholly on the retinacular and foveolar vessels It seems reasonable to assume that displacement of the fragments is greatest when the fracture line is vertical, and least when it is more horizontal, especially when there is impaction of the fragments The fracture-shaft angle may be accepted as an index of the degree of displacement, and probably therefore as a guide to the likelihood of damage to the retinacular arteries The statistics of Eyre-Brook and Pridie (1941) suggest that when the fracture-shaft angle is greater than 40 degrees, displacement of the fragments is insufficient to cause disruption of the retinacular vessels

It is difficult to estimate the frequency with which the adult femoral head can be nourished fully by the foveolar artery There is a variable foveolar supply in 70 per cent of cases, the vessels being capable of maintaining the nutrition of the whole femoral head in some cases (Schmorl 1924, Hesse 1925, Santos 1930), and of no more than a limited area near the fovea in others In the other 30 per cent, loss of the retinacular supply would be expected to cause avascular necrosis

One patient who died four months after fracture of the femoral neck showed the importance of the foveolar vessels There was complete disruption of the retinacular vessels but the foveolar vessels were intact The medial third of the head was alive, the other two-thirds, which had died, was already revascularised fully from the living segment and new bone was being laid down on the dead trabeculae There is of course abundant evidence that, in the adult, complete regeneration is slow and usually incomplete, especially when the avascular fragment is large (Phemister 1939) Only when there are large foveolar vessels is vitality of the head likely to be maintained to a degree compatible with a good end-result It must not be forgotten, however, that proper reduction and immobilisation of the fracture may also assist in revascularisation of the proximal fragment Clearly, every effort should be made to avoid damage to the fovealar arteries

Avascular necrosis due to the Smith-Petersen nail—There is no direct evidence as to the way in which the foveolar supply may be affected by a Smith-Petersen nail Linton (1944) suggested

that there was significant difference in the incidence of necrosis as between cases treated by means of a Smith-Petersen nail and those immobilised by Nystrom's three small nail Avascular necrosis occurred in 39 5 per cent of fractures treated by the massive nail and only in 9 3 per cent of fractures immobilised by small nails The explanation seems to be obvious Any object driven into the bone near the fovea may disrupt the foveolar vessel. Furthermore, in so far as the anterior part of the head usually receives its blood supply from the posterior set of retinacular vessels, a large centrally placed object may sever intra-osseous arteries The foveolar vessels are most prone to damage if the nail is near the fovea and with its tip flush with the articular surface Nystrom's nails, and Austin Moore's pins, are inserted more peripherally than the Smith-Petersen nail and their bulk is dispersed, for this reason they are likely to cause less damage The risk of a Smith-Petersen nail may perhaps be reduced by inserting it eccentrically and avoiding the foveolar area

Traumatic dislocation of the hip joint—There is little evidence as to the incidence of vascular damage in traumatic dislocation of the hip joint Kleinberg (1944) reported a case in which the foveolar vessels were still patent after such injury, but in the majority of cases the ligamentum teres must be ruptured so that there can be no vascular supply to the femoral head from foveolar vessels The incidence of avascular necrosis must depend first upon the frequency of damage to retinacular vessels, and then upon the incidence of anastomosis between these vessels and the nutrient arteries In children no nutrient vessel was detected crossing the epiphysial line from the metaphysis to the epiphysis In some adults, however, there was such anastomosis Thus, avascular necrosis after traumatic dislocation of the hip joint, due to rupture of the retinacular vessels in cases where there is no adequate anastomosis between these vessels and the nutrient artery, must be expected to occur more frequently in children than in adults

SUMMARY

1 The arterial supply of the upper end of the femur has been studied in twenty four children and twenty adults

2 The arterial system was demonstrated by injection of radio-opaque material, with Spalteholz' method of clarification, and histological section of the neck and ligamentum teres

3 The upper end of the femur is supplied by the nutrient artery of the shaft, the retinacular vessels of the capsule, and the foveolar artery of the ligamentum teres

4 The retinacular vessels consist of three separate groups postero-superior, postero-inferior, and anterior These vessels are the chief supply to the epiphysis and femoral head at all ages

5 The foveolar artery constitutes a small and subsidiary blood supply to the femoral epiphysis In this series, it penetrated the cartilaginous or osseous head in 33 per cent of young specimens and 70 per cent of adult specimens The foveolar vessels increase in size with age

6 The site of the vascular pathology in various lesions of the femoral head is considered

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ALKALINE PHOSPHATASE AND THE MECHANISM OF OSSIFICATION

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In bone formation, two fundamental processes may be distinguished—the synthesis of a calcifiable protein matrix, and the deposition of mineral salts therein The biochemical mechanism by which bone salts are formed and deposited has been studied extensively since Robison's first description of a "bone enzyme," with an optimum pH in the region of 9, which was referred to later as "alkaline phosphatase" In this paper it is proposed to outline earlier work which forms the background to recent intensive studies of alkaline phosphatase, and to survey the contribution of histochemical studies to our understanding of the complex processes of calcification and ossification

Investigation of the biochemical mechanism of calcification was initiated in 1923 by Robison's description of an enzyme which was capable of hydrolysing phosphoric esters *in vitro* Roche (1946) reviewed Robison's work in the light of more recent research, and only the facts which are relevant to histochemical studies will be discussed here In his study of calcification, Robison took slices of the epiphyses of long bones of rachitic rats and incubated them in physiological solutions with different concentrations of calcium and phosphorus salts The bone slices were then fixed, and the deposits of inorganic phosphate were visualised by conversion to silver phosphate which is darkened by light It was found that, under favourable conditions, inorganic phosphate was deposited during incubation in the region of the hypertrophic cartilage at the epiphysial junction This method was useful in showing the distribution of calcified areas and the conditions which determined calcification Calcium phosphate was deposited only when the product of ion concentrations of calcium and phosphorus in the solution exceeded 40 mg per 100 ml Below this level, calcification occurred only if sufficient phosphoric ester was added to the medium Addition of the ester also encouraged the deposition of calcium phosphate at higher ion levels It was this observation, as well as the fact that a phosphoric esterase could be extracted from bone, which led Robison to formulate his well-known theory of calcification which may be stated briefly 'A phosphomonoesterase is present at the site of calcification This enzyme liberates phosphate ions from organic phosphates, thus producing a local increase in the concentration of phosphate ions Consequently the solubility product of calcium phosphate is exceeded and the salt is precipitated at the site of enzyme action' This theory requires the presence of active phosphatase at the sites of calcification only, and a suitable substrate in sufficient concentration to produce the required phosphate ions These conditions being fulfilled, local precipitation of bone salts might be accounted for, but fixation of the salts in the protein matrix would still have to be explained This aspect of the problem was investigated by Roche (1946) whose modified theory of calcification is set out in his review

In order to demonstrate the presence of phosphatase at sites of calcification, quantitative biochemical methods were at first employed These were based on estimates of the phosphate, or of the organic radicle liberated by enzymic hydrolysis of a suitable substrate They can be applied either to macerated tissues or to more or less purified enzyme extracts When minute portions of tissue are used for analysis, a fair idea of the distribution of enzyme within an organ can be determined

When examining the results of quantitative enzyme studies, certain difficulties must be borne in mind Enzyme activity is influenced by the mode of preparation of tissues and the methods of purification This was emphasized by Thoai, Roche, and Roger (1947) who showed that the effect of certain activators on alkaline phosphatase was altered by the

method of extracting the enzyme When dealing with extracts, incomplete removal of enzyme from the tissue is unavoidable and there is always the possibility that there may be unknown quantities of tissue constituents exerting an influence on the enzyme action These discrepancies may become evident when the enzyme activity of different tissues is compared

Results obtained by biochemical assay deal necessarily with organs or parts of organs the heterogeneous nature of the tissues is not taken into account Robison's bone slice technique was the first method by which localisation of phosphatase within a tissue was demonstrated Calcification took place in the hypertrophic cartilage of rachitic bones hence this tissue must be the site of enzyme action Fell and Robison (1929) examined embryonic bone grown in tissue culture, and again demonstrated the association of alkaline phosphatase with hypertrophic cartilage and its absence from small-celled cartilage Experiments on membrane bone formation showed that phosphatase was always present in the ossifying mesenchyme Fell and Robison concluded that phosphatase was synthesised by hypertrophic cartilage cells and osteoblasts

Robison's bone slice technique may be called a microanatomical method and it was the precursor of the histochemical technique developed fifteen years later by Gomori (1939) and Takamatsu (1939) The advantage of this method is the accuracy with which the enzyme can be located, not only at sites within a tissue but also on particular structures inside cells Paraffin sections of the tissues which were fixed in 80 per cent ethyl alcohol are dewaxed and incubated in an alkaline medium containing sodium β glycerophosphate and calcium ions By the action of phosphatase, inorganic phosphate is split off and calcium phosphate is deposited at the site of enzyme action The white calcium phosphate is then visualised by conversion either to the silver salt or to the black cobalt sulphide The latter method gives more constant results and it may be illustrated by the scheme

$$\begin{array}{ccl} \text{Na } \beta \text{ glycerophosphate} & \xrightarrow[\text{pH } 9]{\text{phosphatase}} & \text{calcium phosphate} \\ +\text{Ca} & & \quad\downarrow \; Co(NO_3)_2 \\ & & \text{cobalt phosphate} \\ & & \quad\downarrow \; (NH_4)_2S \\ & & \text{cobalt sulphide} \end{array}$$

The Gomori method has been used so extensively on almost every type of tissue (Lison 1948) that we must consider whether the conclusion is justified that black areas do in fact represent phosphatase activity It had been known for some time that phosphatase was not destroyed by treatment with alcohol (Robison, Macleod, and Rosenheim 1930) so that fixation of the tissue should not greatly impair its enzyme activity On the other hand, paraffin embedding, with exposure to a temperature of about 58° C for several hours, is certain to affect the enzyme adversely But the destructive effect is of no great importance provided that there is no *specific* destruction at certain sites, nor diffusion of the enzyme from its original location That there was no such destruction or diffusion has been shown by Danielli (1946) who concluded that " alkaline phosphatase in fixed preparations is found at sites which are those in which it occurs under physiological conditions " The method is not strictly quantitative but the degree of blackness in identically treated sections does provide an index of the relative phosphatase activity Incubation is carried out at pH 9 to 9 3—that is to say the optimum pH of the enzyme the method is not reliable with hydrogen ion concentrations at a more physiological level (Danielli, personal communication) " Gomori negative " areas (without colour) are not necessarily devoid of phosphatase Moreover, since the conditions within a tissue are not always optimal for the action of alkaline phosphatase, we must not conclude that every cell which is " Gomori positive " displays enzyme activity *in vivo* Indeed it is likely that the conditions for phosphatase action in the cytoplasm are not favourable (Danielli 1946) Modifications of the Gomori method, such as changes in the substrate or the pH, must be regarded with caution until the validity of these methods has been demonstrated

The histochemical method was first applied to non-osseous tissues, both normal and pathological The results will not be discussed here, but it must be borne in mind that phosphatase is present in many structures, particularly in the brush borders of proximal renal tubules and the intestinal mucosa, as well as in most cell nuclei Hence it is clear that phosphatase has other functions than that of its probable rôle in calcification. It remains to be determined what those functions may be, and what it is that determines calcification in certain tissues and prevents it in other tissues which contain phosphatase

In applying the Gomori method to calcified tissues there are certain technical difficulties Phosphatase is destroyed by ordinary methods of decalcification On the other hand, in sections of undecalcified osseous tissue, which can of course be obtained only from young material, the calcium salts already present obscure the phosphatase reaction, since both appear black after treatment by the Gomori method Gomori modified his technique in such a way as to stain preformed phosphate black but the sites of phosphatase activity purple

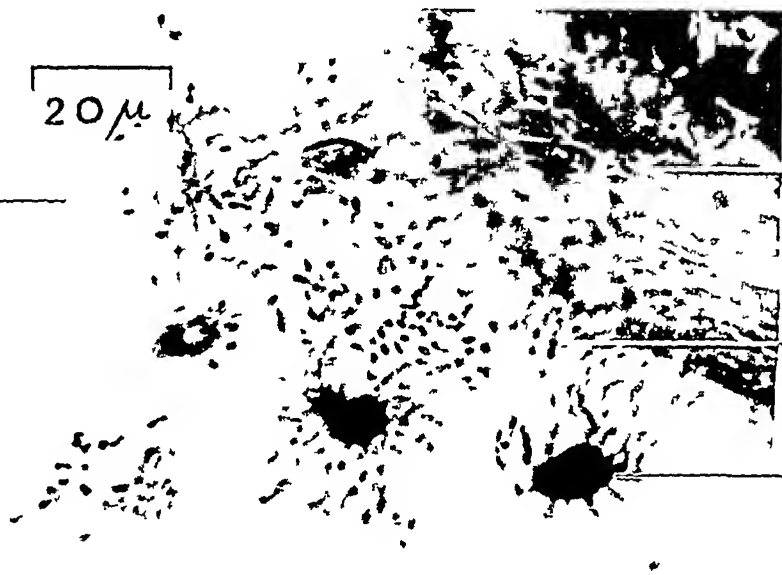

FIG 1

Compact bone of rat's rib near the marrow cavity Incubation time one hour Note the osteocytes with processes and positively staining fibres extending from the endosteum (Untouched photomicrograph of decalcified section Sites of alkaline phosphatase, displayed by the Gomori method appear black)

(Gomori 1943) The results, obtained with bones of various mammalian embryos, agree well with Robison's conception of an enzyme associated with ossifying cartilage and developing membrane bone Gomori found that phosphatase appeared first in the perichondrium of vertebrae and ribs, and later in that of all cartilages which become ossified Subsequently the cartilage cell nuclei and the matrix were positive, particularly in the region of the perichondrium In these areas, calcium salts are first deposited

Bourne (1943) tried to overcome the technical difficulties by incubating bone slices in the Gomori substrate and decalcifying *after* visualising the phosphatase Owing to the possibility of diffusion during various stages of the procedure, these results cannot be accepted as cytologically accurate Nevertheless the observations of Bourne agreed in general with those of Gomori

Moog (1944) found that phosphatase was distributed widely in early chick embryos but that later it became localised in certain tissues, particularly those which were about to

ossify She confirmed the results of Fell and Robison (1929) that phosphatase was invariably present in hypertrophic cartilage Horowitz (1942), working on the heads of foetal rats, demonstrated clearly the association of phosphatase with developing bones and teeth He indicated that glycogen, which was also localised in these tissues, might provide a substrate for the enzyme, but more evidence is needed on this point

There have been no histochemical investigations of phosphatase in animals beyond a certain stage of development owing to the difficulties experienced in cutting thin, undecalcified sections of the harder material This prompted me to develop a method of decalcification which would not destroy the enzyme (Lorch 1946, 1947) The method involves decalcification by citrate buffer at pH 4 5 in the presence of zinc ions which have a protective effect on the enzyme The slight degree of inactivation which occurs during this treatment can be reversed by subsequent reactivation in an alkaline medium The results obtained by applying this

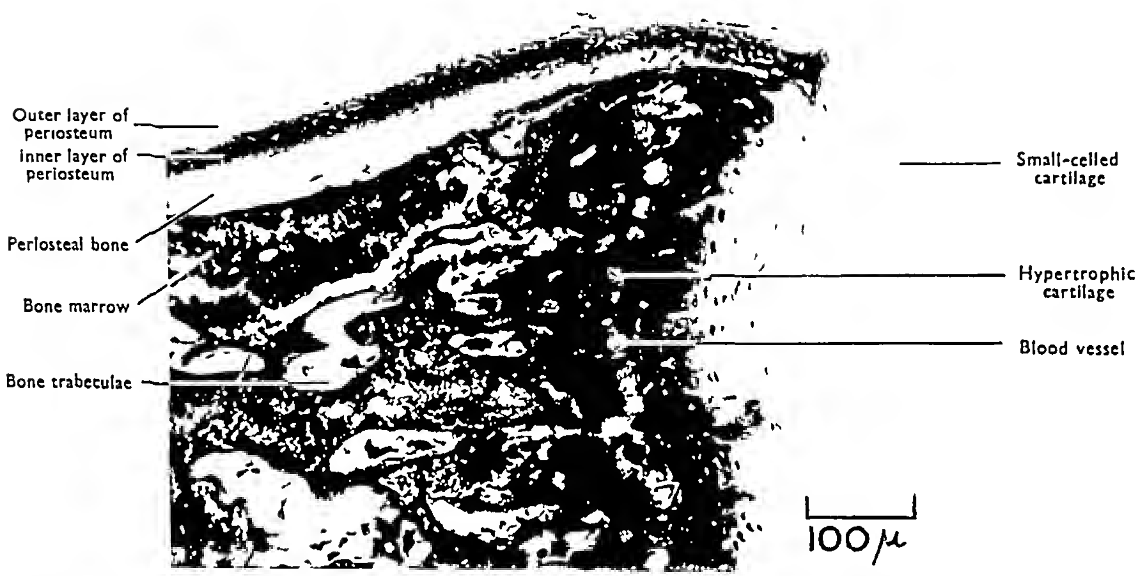

FIG 2

Costochondral junction from rib of adult rat Incubation time, thirty minutes Note the absence of phosphatase from the small-celled cartilage except for a few nuclei in the central zone The nuclei of hypertrophic cartilage cells are strongly positive The inner layer of the periosteum is positive the compact periosteal bone immediately below it is negative There are a few positive patches in the bony trabeculae (Untouched photomicrograph of decalcified section Sites of alkaline phosphatase displayed by the Gomori method, appear black)

method to bones of kittens and adult rats and mice (Lorch 1947) may now be summarised Phosphatase is concentrated in the endosteum and periosteum where it appears in the nuclei of fibroblasts and on collagenous fibres The bone matrix itself is negative, except in some newly formed trabeculae where traces of enzyme could be detected The superficially placed osteocytes have long ramifications protruding into the matrix These spidery, phosphatase-containing cells stand out black against the colourless bone matrix (Fig 1) At the costochondral junction of the ribs, as well as at the epiphysial plate of rodent bones, phosphatase is localised in hypertrophic cartilage cells and in the calcifying matrix (Fig 2) It will be noted that small-celled cartilage and periosteal bone were completely negative Some bone marrow cells contained phosphatase Greep, Fischer, and Morse (1948) gave an account of the distribution of phosphatase in decalcified sections of the tibia and skull bones of growing rats Their results are in agreement with my observations

Recently, a study of phosphatase in the skeleton of developing bony and cartilaginou fish was made (Lorch 1949) The results indicate that, in the earlier stages of development phosphatase is very widespread but is confined almost entirely to the nuclei Extracellula phosphatase appears only at sites of calcification or fibre formation This finding is of interes in view of the fact that the collagenous fibres of healing wounds also show strong phosphatas activity (Fell and Danielli 1943) Similar observations were made on fracture callus b Bourne (1943, 1948) It would seem, therefore, that phosphatase may have at least tw functions, apart from its intranuclear rôle which is possibly concerned with nucleic aci metabolism, namely, the initiation of calcification, and some rôle in connection with fibr formation

In the bony fish (trout) phosphatase always appeared at the sites of membrane bon formation long before the actual bone was defined The pre-osseous matrix displayed phosphatase activity but the older bone was invariably negative except in the periosteum

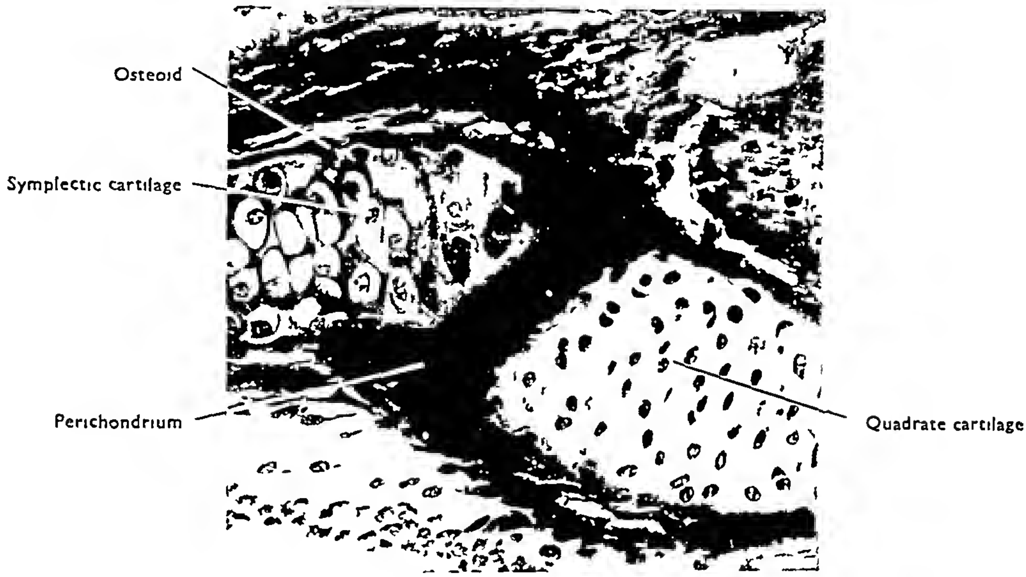

Fig 3

Distal end of the quadrate cartilage at its articulation with the symplectic process of a 20 millimetre trout Incubation time six hours Only the symplectic cartilage is surrounded by a layer of osteoid Note the difference in appearance and phosphatase content between ossifying and non-ossifying cartilage (Untouched photomicrograph of decalcified section Sites of alkaline phosphatase displayed by the Gomori method appear black)

This is in agreement with findings on mammalian bones In cartilage bone formation phosphatase appeared in the enlarged cartilage cells, and in the matrix, simultaneously with the formation of a periochondral ring of osteoid Non-ossifying cartilage never displayed extracellular phosphatase, only the nuclei of the chondrocytes being positive as are those of many other tissues The contrast between ossifying and non-ossifying cartilage is seen in Fig 3

In the cartilages of non-bony fish (Scyllium canicula) phosphatase was strictly localised at the periphery, where the platelet-like deposits of calcium salts occur during the late embryonic stage In young embryos, devoid of calcium deposits, the cartilage was free from phosphatase It is evident that phosphatase is correlated with calcification even in the absence of actual bone formation

Since calcification in dogfish, trout, or mammals has never been observed at sites devoid of extracellular phosphatase, there is definite evidence that the latter is an essential factor Intracellular phosphatase does not seem to be correlated with calcification A knowledge of

the phosphatase mechanism alone cannot lead to full understanding of the complex processes of calcification and ossification Research into the nature of the protein matrix of bone and the other factors which play a part in the precipitation and fixation of " bone salts " would seem most profitable at this stage of our knowledge of the biochemistry of ossification

Figs 1 and 2 are reprinted from the Quarterly Journal of Microscopical Science, 88, by kind permission of the Company of Biologists

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THE MOVEMENTS OF BONES AND JOINTS

2 Function of the Musculature

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Muscles retain the bones of a joint in a given position (postural function) or they change that position for another (phasic function) Each of these functions is carried out in a field which is influenced by gravity The distinction between postural and phasic functions is not simply academic, for it is reflected in the arrangement and the action of the muscles themselves The terms "shunt function" and "spurt function" are more descriptive *Shunt* refers to the force which is transmitted along the bone in the direction of the joint, while *spurt* refers to the force which pulls the bone along the curved path which it traverses during movement These words were introduced into mechanics by English engineers in the nineteenth century "Shunt" is the centripetal force associated with movement in a curve, while "spurt" is the force which acts along the tangent to that curve As a general rule it is possible to distinguish shunt muscles from spurt muscles by simple inspection of their anatomical arrangement

SHUNT MUSCLES AND SPURT MUSCLES

A shunt muscle is one that directs more of its contractile force along the bone than across it, whereas a spurt muscle directs more of its force across the bone than along it The distinction becomes effective as soon as the joint moves from the position of full extension to one in which the bones make an angle with each other (Fig 1) A muscle which arises near the joint and is inserted far from it is clearly a shunt muscle On the other hand, a muscle which arises far from the joint and is inserted near to it is a spurt muscle There are very few, if any, muscles with origins and insertions equidistant from the joints on which they act This is true even for the adductor magnus muscle, which at first appears to be an exception to the rule The most anterior pubic fibres of this muscle are spurt muscles, whereas the most posterior ischial fibres are shunt muscles The biceps brachii and the brachialis anticus are spurt muscles, the pronator teres and the brachio-radialis are shunt muscles From these examples it is clear that the difference between these two types is the relative distance from the joint of their origins and insertions The reason for the distinction in main action of the two kinds of muscle is, of course, that muscles whose length beyond the joint is greater than that above it remain more nearly parallel to the moving bone than do those of the opposite type, and thus direct more of their force along the bone It is possible to develop the thesis in a mathematically precise manner (MacConaill 1946), but this is not necessary for the practical grasp and application of the principle This principle finds two chief applications, namely, a mechanical basis which explains the sites of tendon sheaths and lumbrico interosseal expansions, and an understanding of the sequence of contraction of the several parts of the musculature of joints

THE FUNCTION OF TENDON SHEATHS

The clinical importance of tendon synovial sheaths has obscured the fact that they are no more than bursae, ancillary to the fibrous sheaths beneath which they run Fibrous sheaths serve the simple purpose of retaining the tendons, and therefore the forces they transmit, close against the bone in all positions of the joint The effect of this function is that the "vaginate" muscles, as we may call them, are shunt rather than spurt muscles,

except for the joints at which they are not ensheathed—for example, the terminal joint of the digit in the case of the flexor longus digitorum This is shown in Fig 2

It will thus be clear that shunt muscles tend to press the bones together rather than move them They are stabilisers rather than mobilisers—postural rather than phasic In this lies the explanation of the stability of ankle and wrist joints over a wide range of posture It makes possible the art of the ballet dancer and the acrobat

THE LUMBRICAL AND INTEROSSEOUS MUSCLES

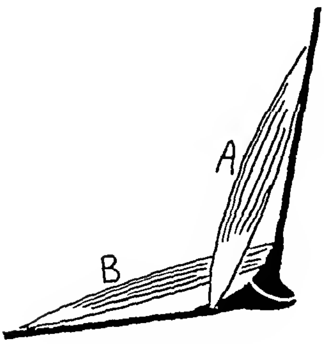

Fig 1

Scheme to show the difference between spurt and shunt muscles The spurt muscle (A) pulls more directly across the bone in most positions other than full extension The shunt muscle (B) pulls more directly along the bone

The instinct of the examination candidate who assigns tendon sheaths to the extensor tendons of the fingers is perhaps more sound than that of the examiner who is deeply shocked The candidate who cannot see why the index-extensor is less entitled to a sheath than, say, the flexor beneath a metatarso-phalangeal joint, is to be forgiven, because the range of angulation at the corresponding joints is comparable In fact, the function served by a flexor sheath is served also by expansions of the lumbrical and interosseous muscles where they are inserted into the proximal parts of the extensor tendon These expansions pull the tendon of the extensor in a palmar (or plantar) direction and thus keep the tendon in close apposition with the bone They form part of the postural mechanism of the joints between the digits and the bulk of the limb, and they enable the fingers (or toes) to be used effectively over a wide range of posture Attachments to the more distal parts of the tendon subserve a similar function at the joints of the fingers For a first-hand account of the effects of nerve injury upon the functions of these muscles the reader is referred to the paper by Sunderland (1945), based upon cases from the Pacific theatre of war

CISARTICULAR AND TRANSARTICULAR LENGTHS

The distance from the origin of a muscle to the axis of movement of a joint may be called the *cisarticular* length, and the distance from that axis to the insertion of the muscle is the *transarticular* length These measurements are made while the muscle is stretched to its full natural length (Fig 3) The ratio of the cisarticular length (C) to the transarticular length (T)—that is to say, the ratio C/T —is a guide to the functional relation of the muscle to the joint When that ratio is greater than unity, as in the muscle A in Fig 1, then the muscle is primarily a spurt muscle, but if the ratio be less than unity, as in the muscle B, then the muscle is primarily a shunt muscle Further proof of these statements will be found in the author's paper (MacConaill 1946) The concept underlying this ratio has a special application to muscles passing over two joints The biceps brachii may be taken as an example

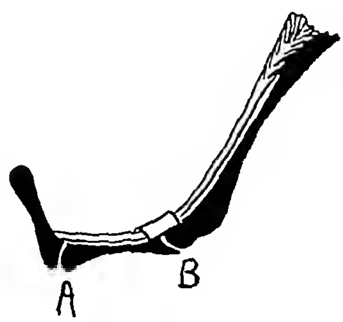

Fig 2

Scheme to show the joint-stabilising action of a fibrous tendon sheath Where there is no sheath (A) the muscle behaves as a spurt muscle Where there is a sheath (B) the muscle being bound to the bones behaves as a shunt muscle

It is a muscle which acts upon the shoulder joint and also on the elbow (its action on the radio-ulnar joint is irrelevant to this discussion) It arises but a short distance above the shoulder and is inserted far distal to it Hence it is a shunt or postural muscle to the shoulder, and this action is enhanced by enclosure in a synovial sheath formed by the joint, and by

the prolongation of the sheath along the bicipital groove On the other hand it arises far above the elbow and is inserted but a short distance distal to it It is therefore a powerful spurt or phasic muscle for the elbow The example of the biceps brachii is extended readily to other muscles which are disposed similarly In particular, Haines (1934) showed that the long head of the biceps femoris had little phasic effect upon the hip joint when it acted as a motor of the knee, and conversely We are led, then, to this general rule *when a muscle acts on two joints it is chiefly a spurt muscle to one and a shunt muscle to the other*

THE REVERSIBILITY OF MUSCLE ACTION

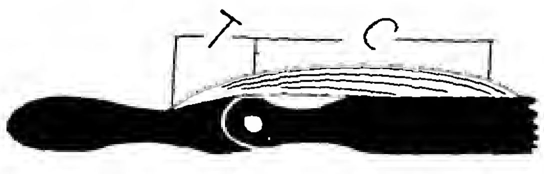

FIG 3

To illustrate the meanings of cisarticular length (C) and transarticular length (T) of a muscle See text The axis of motion of the joint is indicated

The effect of a muscle in moving a bone depends solely upon the moment of its contractile force taken about the axis of movement at the joint The magnitude of this moment is independent of the direction of contraction of the muscle fibres, whether they act from the origin or from the insertion So far as spurt action is concerned, the muscles are therefore reversible But their shunt action is not reversible, for in general their cisarticular and transarticular lengths are unequal, and the greater the shunt effect when they act from anatomical origins, the less will be that effect when they act from anatomical insertions The cisarticular length then becomes the transarticular, and conversely This restriction does not hold for muscles which have sheathed tendons, nor for those which have lumbrical and interosseous tendons inserted into them Apart from these exceptions, it appears that the spurt muscles which are prime movers, and shunt muscles which are joint approximators, interchange their rôles with reversal of their directions of contraction That is to say, the musculature of a joint is mechanically reversible as a whole, but not by parts

THE RELATION OF GRAVITY TO THE MUSCULATURE

The influence of gravity is a constant factor in our environment, and the power of muscles must overcome this force as well as move the limb The weight of the parts moved by muscles may often be comparable with the maximal extraneous loads put upon them This fact has to be kept in mind in attempts at numerical assessment of muscular force and efficiency Weight-lifting tests measure the reserve power, rather than the absolute force, of the muscles and are thus analogous to the tests which an ophthalmologist makes upon the oculomotor apparatus of a patient suspected of squint

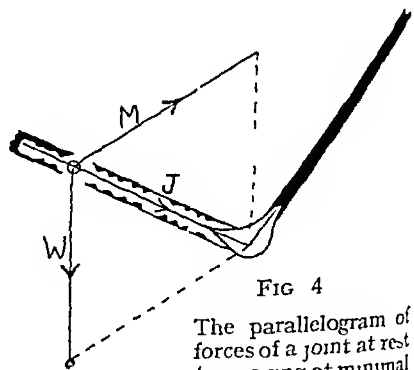

FIG 4

The parallelogram of forces of a joint at rest (or moving at minimal uniform speed)

(W) Total load (weight of moving part of limb *plus* extraneous load) (M) Muscular force required to keep the part at rest, shown acting through centre of gravity of the moving part This is the resultant of all the actual muscle forces in operation (J) The resultant of the other two forces acting across the joint It is shown in the text to be equal in magnitude to the total load

In all important cases the weight of the limb, with or without an added load, is one of the two forces which have a resultant directed towards the centre of the joint (Fig 4) The other force is the resultant of all muscle forces in action at the time, it acts at the centre of gravity which varies with the total load, but is fixed for any given load We have thus the directional lines of a parallelogram of forces which could be drawn to scale if the ratio J/W were known, J and W being the total shunt force and the total load respectively The law which underlies the concept of this parallelogram is that musculature balances the pull of gravity whether the joint be at rest or in uniform motion

It is an anatomical fact that the form and structure of a joint is such that the swinging limb is not retained automatically, the active assistance of muscles is required that is to say, the centripetal or shunt force which must be present when we have movement along a curve, has to be supplied by the musculature * In so far as this is true, the shunt force, J, will be constant during uniform movement In accordance with the laws of physics the amount will be proportional to the square of the rate of turn of the bone about the axis of the joint

What then is the value of J when the joint is not moving? It appears that it may be equal to the total load, W The argument is thus there is a minimal possible degree of tonus of the musculature, consistent with security of the joint When the arm is hanging vertically and this tonus is present, the part is on the threshold of "pendulum swing," and the centripetal force which balances the weight is equal to W This "pendulum" has its proper rate of swing A pendulum swings through a small arc, but the joint can be moved over a large arc at the same rate *and therefore with the same centripetal force* as is proper to the pendulum swing That is, in the limit, when the joint is at rest the inward or shunt force is equal to the load (W) and *is constant for all positions of the joint*

It follows that when the weight of the part is acting vertically downwards upon the joint, as in the upraised forearm or on the ankle in standing, the prime movers or spurt muscles will be in minimal action This is well known and has been applied admirably to the rehabilitation of cases of infantile cerebral palsy by Phelps and his school (Collis 1947) This agreement between expectation and event does not of itself demonstrate the truth of the argument Further evidence of a confirmatory nature is available if the sequence of contraction of the several muscles concerned with known movements is considered

THE SEQUENCES OF MUSCULAR CONTRACTION

Let it be assumed that the law stated above is true, and that the musculature of a joint which is at rest combines with gravity to give a force directed towards the joint along the bone, that force being the same for all positions of the joint It will be the force which acts centripetally throughout the slowest possible uniform movement of the joint Any more rapid movement will require a greater shunt force to act along the bone That force cannot be provided by the spurt muscles, for they would impart an acceleration *along the curve* as well as one along the bone This possibility is excluded by the uniform nature of the movement The only muscles which are available are the typical shunt muscles, that is to say, those with origins closer to the joint than the prime movers Thus we should expect that the biceps, brachialis, pronator teres, and the brachio-radialis, would come into increased contraction in that order, and this can easily be felt and seen to be the case These four muscles are, of course, contracted to some extent throughout the movement, it is an increase of contraction which is to be looked for in each case The difference between the order of contraction of the biceps and the brachio-radialis is most easily observed, as one would expect on grounds of surface anatomy The experiment is to be checked by asking the subject to place his hands upon, say, the top of a door and then to pull himself up slowly, by bending his elbows The brachio-radialis will then be seen to come into marked contraction in advance of marked contraction of the biceps, for the rôles of spurt and shunt muscles have been reversed It should be added that the ease of observation of muscular contraction in the first case (forearm "free") is much aided by making the subject raise a moderately heavy weight We can therefore summarise the rôle of the musculature by saying that spurt muscles are also anti-gravity muscles in positions other than nearly complete extension, while shunt muscles, as the name implies, have a special part to play in rapid swing at the joint

* For practical purposes the arc of movement may be regarded as the arc of a circle

It is understood, of course, that moving the limb against gravity calls for acceleration at the start of the movement Very often, such acceleration seems to be gained by no more than inhibition of the antagonistic fibres An experiment is instructive, it has to be carried out upon the experimenter himself Practise relaxing the muscles, especially those of the upper limb in particular, let the arms hang heavily by the sides, sit—or better, stand—with the two arms hanging by the sides in that way, now " let them bend " at the elbows, do not even try to " bend " them actively If the shoulder muscles be relaxed completely the forearms will be felt to " float " upwards, much as if they were floating in salt water The sensation is remarkable and quite different from that of deliberate flexion It is possible to attain considerable angulation of the elbow in this way The eyes should, if possible, be fixed upon a distant object so that the utmost detachment from the normal psychological concomitants of cubital flexion may be attained

The experiment may be repeated with the fists clenched There will be a slight, but perceptible, increase in the speed of flexion of the elbow The two experiments demonstrate the rôle of shunt muscles, for clenching the fingers increases preliminary tone of the wrist and finger flexors which pass over the elbow, and these are part of the shunt musculature of the elbow

This account is not intended to be an exhaustive survey of muscular action, it is intended as no more than an introduction to the mechanism of the synovial joints, a mechanism in which the concept of spurt and shunt muscles will be seen to have a particular relevance and value Attention has been given chiefly to aspects of muscular arrangement and action which have been treated either lightly or not at all in standard works upon the subject The purpose of the writer will have been served if others are stimulated to question the statements made upon the grounds of fresh experiment

SUMMARY

1 Muscles acting upon any joint can be divided into two principal groups muscles of displacement or spurt muscles, and muscles of stabilisation or shunt muscles

2 Muscles which arise far from the joint are spurt muscles, those which arise near it are shunt muscles

3 The fibrous tendon sheaths are joint-stabilising mechanisms

4 The lumbrical and interosseous muscles are muscles of stabilisation of the digits

5 The arrangement of the musculature is such as to ensure a constant pressure across the joint cavity during rest or uniform movement The necessary centripetal force during movement is supplied mainly by the shunt muscles

6 Experiments are described to illustrate these observations

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7 DIAPHYSIAL ACLASIS

Synonyms—Multiple exostoses, Hereditary deforming chondrodysplasia

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The condition to which the name of diaphysial aclasis was given by Keith (1919), at the suggestion of a friend, is characterised by the presence of cancellous exostoses capped with cartilage, and by failure on the part of the periosteum to model the metaphyses of long bones in a normal manner Diaphysial aclasis and dyschondroplasia are often regarded as variations of one and the same developmental error and they are frequently confused, but with little if any justification Both result from a fault of the epiphysial plate—nests of cartilage becoming misplaced, instead of being calcified and ossified in the normal manner—but radiographically they are quite different and in the vast majority of cases they are distinguishable without the slightest difficulty Exostoses are outgrowths of cancellous bone on the surface of the parent bone dyschondroplasia, on the other hand, is characterised by columns or masses of cartilage lying inside the metaphyses, that is to say, the lesions are essentially endosteal

Hereditary and familial influences play a definite part in the incidence Stocks and Barrington (1925) found evidence of hereditary factors in 65 per cent of 1,102 cases It may be transmitted by both males and females, and is said to affect about half the offspring of a person showing evidence of the condition It has been traced through as many as five generations (Reinecke 1891)

Sex—Of the reported cases, two-thirds are males *Age*—Though sometimes present at birth, it seldom causes trouble before the age of six years and perhaps not till after growth has ceased *Etiology*—The cause is entirely unknown

Incidence—The number of exostoses in a single patient may vary from one to a thousand (Stocks and Barrington 1925), one or two dozen are quite common The size also varies considerably A single exostosis may grow to a size sufficient to give rise to symptoms, and so may two or three exostoses in a multiple case although most of them remain too small to be of clinical importance The bones affected chiefly, but not exclusively as suggested by Keith, are the long bones which are formed in cartilage with help from the periosteum The exostoses project from the surface of the metaphyses or adjacent parts of the shafts, and are particularly common near the ends at which growth is greatest The more recent the outgrowth, the nearer it lies to the epiphysial line—the distance naturally increasing as the bone grows Exostoses attached to the middle third of the shaft of a long bone—a site indicating very early origin—are rare The epiphyses are never the seat of exostoses The most common sites are the femur and tibia in the region of the knee joint, the upper end of the humerus, both ends of the fibula, and the lower ends of the radius and ulna The pelvis (most commonly the ilia), the clavicles, sternum, spine, mandible, ribs (anterior ends), carpus, tarsus, and scapulae, show outgrowths less frequently Exostoses are seldom seen in the neighbourhood of the elbow joint In the spine it is the neural arches that are affected, and only very seldom a vertebral body, spinal exostoses are usually small The author has seen only two cases with large exostoses of the spine The metacarpals and phalanges may show small projections from the cortex, usually close to the epiphysial lines, though occasionally nearer the centre of the shaft, but the changes are insignificant and they are in sharp contrast to the crippling deformities of the fingers which are often produced by the enchondromata of dyschondroplasia In a few cases exostoses have been described on the sternum, and in the sub-occipital and mastoid regions of the skull they may even occur on the vertex of the skull,

when they are said to be similar to isolated cranial osteomata (Stocks and Barrington 1925)

Dwarfing—There is often, but by no means always, a varying degree of general dwarfing There may be inequality in the length of the limbs, though it is not always the more affected which is the shorter

Symptoms and signs—Most of the exostoses cause no symptoms, but a few, from their size and position, give rise to some discomfort in surrounding structures For instance an exostosis on the inner side of the femur or tibia may cause inconvenience by pressure against the other leg, or against a saddle during riding A muscle or tendon may slip to and fro over the bony projection and produce an inflammatory reaction in the bursa covering the cartilage cap Occasionally, abrupt slipping of a tendon produces a snap, and this may even cause temporary "locking" of the adjacent joint Advice may be sought by reason of pain, impaired function, size of the growth, or deformity, and, in quite exceptional cases, interference with a nerve or artery Very occasionally paraplegia has resulted from the pressure of a vertebral exostosis, usually one situated in the cervical region In common with certain other conditions, the ulna is often unduly short, with its lower end imperfectly developed and with an exostosis projecting from the lower third of one or both forearm bones The shaft of the radius is curved and the head of the bone is not infrequently dislocated Even when there is no such dislocation, the relative position of the humeral condyles may be abnormal The lower articular surface of the radius is tilted inwards, and there is displacement inwards of the carpus but usually without ulnar deviation of the hand Deformity of the forearm may be unilateral or bilateral The fibula may be short, but much less frequently than the ulna Shortening of the fibula is more often obvious at the upper end than at the lower, unaccompanied by deformity of the tibia The lower ends of the tibia and fibula, distorted by bony outgrowths, are sometimes said to be fused, but if true fusion occurs at all it is very rare

Radiographic appearances—Radiographs show that individual exostoses have broad bases fused with the shaft of the parent bone Some are sessile projections, but when the exostosis is well formed the shape is always characteristic on the side nearer the centre of the shaft the projection of bone rises abruptly, almost at right-angles to the surface of the shaft, whereas on the other side it slopes gradually towards the epiphysis The apex is directed towards the centre of the bone, and though occasionally ending in a sharp point it is more often rounded with a tendency to become enlarged or mushroomed Sometimes the enlargement is irregular and resembles a cauliflower An important additional feature, often absent when there are no more than one or two exostoses but always seen when these are numerous, is irregular enlargement and abnormal shape of the metaphyses and adjacent parts of the shafts The periosteum has failed to model the bone properly, and the normal trumpet-shape of the end of the shaft is distorted and often lost Occasionally, exostoses on the superficial and deep surfaces of an enlarged metaphysis may produce such irregularity in density of the radiographic shadow as to suggest cavitation of the bone, and possibly lead to an erroneous diagnosis of dyschondroplasia

Pathology—As already indicated, two abnormal processes are concerned in diaphysial aclasis One or more fragments of cartilage from the margin of an epiphysial line, becoming isolated on the surface of the metaphysis, proliferate and form exostoses, and the periosteum which is incomplete at the sites of these cartilaginous "nests," fails to model the metaphysis in a normal manner It was this periosteal failure which first suggested the word "aclasis" in the title

Histological examination—On section, an exostosis is seen to consist of cancellous bone directly continuous with the parent bone, the apex being covered with a cap of cartilage from which it grows and which merges with the thickened periosteum surrounding its base The cartilage cap is covered by a bursa which may become enlarged as a result of recurrent injury from an adjacent muscle or tendon When an exostosis is large, and shaped irregularly

like a cauliflower, the cartilage instead of forming a smooth cap dips into all the crevices, with the result that section shows an apparently indiscriminate mixture of bone and cartilage In one case of multiple exostoses with excessively large outgrowths from the posterior surfaces of the upper ends of both tibiae, and another of a solitary, large exostosis growing from the neural arch of the fourth lumbar vertebra, the author found on section nodules of cartilage, some of them calcified, buried in the loose cancellous bone of the exostosis This unusual finding does not, however, seem to warrant the assumption that in such cases there was a combination of the two conditions, diaphysial aclasis and dyschondroplasia

Progress and complications—Though an exostosis may enlarge slowly throughout the time that the shaft continues to grow, the rate of growth of different exostoses in a multiple case seems to vary considerably Many show little, if any, change over a period of years, whereas two or three may reach a size capable of causing inconvenience Occasionally one will grow to a considerable size, the enlarged head becoming irregular and even branched Such changes usually occur in a solitary exostosis, particularly if it is growing from the scapula or pelvis In the vast majority of cases, when growth of the skeleton ceases and the adjacent epiphysis fuses with the shaft, the exostosis ceases to grow and the cap becomes ossified Occasionally, however, the cartilage on one of the exostoses may continue to proliferate and become so active as to form a rapidly enlarging chondromatous tumour On section, foci of calcification and ossification may be found in the substance of the tumour Enlargement of an exostosis may be delayed for many years and then begin suddenly, long after growth should have finally ceased The rapidity with which there is increase in size of some of these chondromata, or osteo-chondromata as they often are, naturally raises the question of possible malignant change Careful microscopic examination after biopsy, or even of the whole tumour after it has been removed, does not always settle the question with certainty Willis (1948) considers that the solitary exostosis—" the commonest tumour of the skeleton "—should be regarded as an osteoma and not simply as a solitary type of the multiple condition, and he remarks that it is " not unusual for it to develop a chondro-sarcoma "

Geschickter and Copeland (1936) reported malignant change in 7 per cent of 262 cases of exostosis, but many of the cases they included do not appear to be examples of the condition which is now being discussed Jaffe (1943) in a small series of twenty-eight cases gave the frequency of malignant change as 11 per cent There must of course be many cases of true exostoses which are seen by clinicians, and even operated upon, which never come to the knowledge of pathologists, and it would seem wise, at present, to admit that although the fact of occasional development of a chondro-sarcoma from the cap of an exostosis must be accepted, the frequency of this complication is unknown Some cases are undoubtedly malignant (Platt 1931, Gardner 1937), the bones most likely to be involved being the femur, the scapula and the pelvis It is not always easy to determine whether a large chondromatous or chondro-sarcomatous tumour has arisen endosteally or in the cartilage cap of an exostosis

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CASE 1—DIAPHYSIAL ACLASIS

(Figs 1–4) Woman, twenty-one years of age Deformity of forearms noticed at the age of eleven years, with some thickening of the fingers six months later There were large numbers of exostoses in the usual situations throughout the skeleton One metacarpal, and a few phalanges, showed small bone outgrowths No material change seen in radiographs during the past eight years

FIG 1

Case 1 Forearms Note the shortening curvature and pointed lower extremity of both ulnae, and secondary curvature of the radii Small exostoses are seen near the lower ends of all four bones and also at the upper ends of both ulnae—an unusual site The difference in length of the two bones is also seen at their upper ends where it has disturbed the relative positions of the trochlea and capitellum in both elbows

FIG 2

Case 1 Left leg, age thirteen years Short fibula with abnormal position of both ends and striking enlargement of upper metaphysis Apparent fusion of the tibia and fibula above and below is probably due to overlap of shadows

FIG 3

Case 1 Right shoulder showing several exostoses of the sharp pointed variety directed towards the centre of the shaft General want of modelling of the metaphysis is not very marked An exostosis is seen on the second rib (no similar projection was seen on the corresponding rib on the left side so that the bone thickening may not be due to the attachment of the serratus magnus)

FIG 4

Case 1 Right knee The lower femoral metaphysis shows irregular enlargement with loss of the normal trumpet-shape and with exostoses projecting from its surface Note the characteristic shape of the exostoses which are inclined towards the centre of the shaft An exostosis on the inner aspect of the tibial head appears to have been fractured

CASE 2—DIAPHYSIAL ACLASIS

(Fig 5) Adult male with exostoses affecting both humeri at about the same level, namely the mid-shaft—an unusual position

CASE 3—DIAPHYSIAL ACLASIS

(Fig 6) Specimen of the femur of a man aged about fifty years, with a mushroomed exostosis growing from the lower metaphysis which shows little want of modelling

Fig 5

Case 2 Humeri, showing sessile exostosis on the right and a pedunculated exostosis of characteristic shape on the left

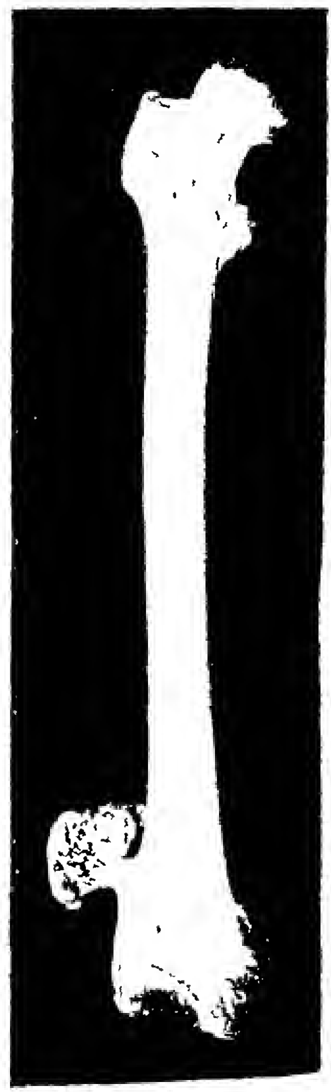

Fig 6

Case 3 Specimen in a man aged about fifty years

CASE 4—DIAPHYSIAL ACLASIS

(Figs 7 and 8) Woman, aged forty-seven years She reported that she had sustained an injury to the left knee six months ago The symptoms were regarded as being due to trauma, and not connected with the presence of exostoses which were principally in the region of the knee joints Only one forearm was deformed

FIG 7

FIG 8

Case 4 The left knee joint (Fig 7) shows imperfect moulding of the femoral metaphysis with two minute exostoses There are other exostoses arising from the tibia and fibula There is evidence of an old fracture of the tibial spine The left forearm (Fig 8) shows marked shortening of the ulna and deformity of the radius with distortion and subluxation of the radial head Note that the carpus is not tilted inwards by the radial deformity

CASE 5—DIAPHYSIAL ACLASIS—with unusual features

(Figs 9–11) Male, aged eighteen years Height, 5 feet 7 inches Lumps on legs were first noticed when he was twelve months old, thereafter gradually growing larger No symptoms until recently Complains of pain in the right thigh on walking Twice in the last few months while cycling, the right knee "clicked" and he was unable to bend it On one occasion the knee locked in extension for a month, movement being regained gradually Exostoses were present on most of the bones including the pelvis, clavicles, several ribs, phalanges, metacarpals, and metatarsals Even the os calcis in each foot was abnormal in shape, with an exostosis on the left The enlargement of the upper part of the calves was enormous, even grotesque The right ulna, and both fibulae, were short Exostoses were removed from the right femur and both calves The tumours in the calves were quite unlike the usual cancellous exostoses, they consisted of open-mesh bone, with the spaces filled for the most part with mushy, gelatinous, and mucoid material, containing here and there patches of cartilage and calcified cartilage

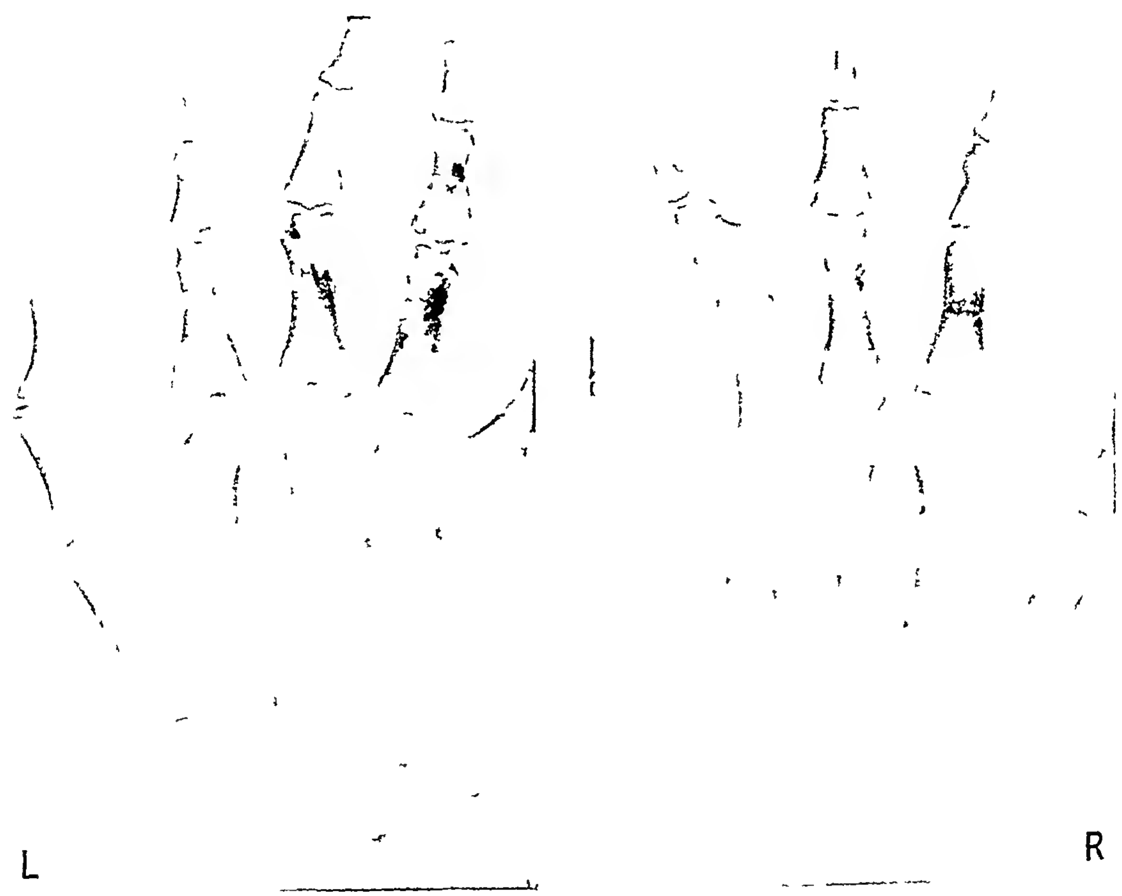

FIG 9

Case 5 Hands showing small exostoses of several phalanges and some metacarpals The left ulna is of normal length The fourth metacarpal of the right hand is short

FIG 10

FIG 10

Case 5 Antero posterior view of the right knee and calf, showing that all three bones are affected The size and irregularity in density of the tibial growth is striking The clear area in the tibia, sharply defined on one aspect, is rather suggestive of cavitation, but at operation this was disproved

FIG 11

FIG 11

Case 5 Left knee showing an exostosis on the posterior aspect of the femur and an extraordinarily large outgrowth from the back of the tibia Note the extensive attachment of the growth to the tibia its nodular surface, and the great irregularity in density Part of the opacity is due to a growth on the fibula

8 DYSPLASIA EPIPHYSIALIS PUNCTATA

Synonyms—Stippled epiphyses, Chondrodystrophia calcificans congenita (Hunermann)

The chief characteristic of this rare disorder of infancy is the presence of a number of discrete centres of unusual density in many cartilaginous epiphyses and apophyses Attention was first called to the condition by this author in 1927, two cases being reported briefly In 1935 he classified it under the title "epiphysial dysplasia puncticularis," this being one of two which, at his request, were suggested by the late Sir Frederick Still The alternative adjective—punctata, which is no less descriptive and was also suggested independently by Dr Parkes Weber (see Bateman 1936), seems to be preferred in this country and it has therefore been adopted Details of eight further British cases are now available, all but one of which have been published by various authors Other cases have been reported under the title of "stippled epiphyses" but the published radiographs do not seem to justify their inclusion in this group Further search has disclosed an undoubted case reported by Conradi in 1914 under the title of "chondrodystrophia foetalis hypoplastica" A few other cases have been reported in the literature of other countries, the title favoured being "chondrodystrophia calcificans congenita" (Hunermann 1931) In all, we have some sixteen cases for study

Hereditary and familial influences—There is no evidence of hereditary influence and seldom of familial influence in the incidence of this condition *Sex*—Females are affected more frequently than males in the proportion of more than two to one

Age—Fourteen cases were discovered within the first nine months, and some within the first few days of post-natal life Only two cases were over two years of age one of these was alive at nine years The dysplasia undoubtedly begins in foetal life

Etiology—The cause of the condition is unknown

Clinical signs—*Dwarfing* of the short limb type is usually, if not invariably, present Th proximal segments of the limbs are particularly short Of two cases in which the change were apparently confined to one lower limb, in one at the age of four weeks the affected lim was short, while in the other, though the legs were equal in length at sixteen months, the was one and a half inches of shortening at the age of nine years Unfortunately full deta are not available in either of these cases The affected epiphyses are definitely enlarg *Contractures*—Flexion of certain joints, with a varying degree of limitation of movemen was present in several cases, the hips, knees, and elbows being the joints particularly affecte In one knee the head of the tibia was subluxated The wrists were held in a flexed positi in one case, and there was ulnar deviation of both hands and rigidity of the wrists in anoth In yet another case there was contracture of the fingers In two cases the hands we described as being long as compared with the forearm, but in another the fingers were blu and inclined to the accoucheur position The feet in one case were rigid although the tar bones were not stippled In one case with involvement of a single leg the foot was valg and stiff In two cases the limbs were said to be "spastic" but without further deta while in a third the reflexes were much exaggerated *Thickening of the skin* is mentioned some German authors In Bateman's first case, the skin of the palms was deeply furro and adherent to the deeper tissues, particularly in the right hand which could not be op completely The *head* has shown no characteristic features, being variously describ normal, rather large, globular, suggestive of oxycephaly, bossed, and even microceph The fontanelle is large The nose in some was broad and the nostrils large *Bilateral cong*

cataract has been a conspicuous feature of the British cases, being found in six of the ten. Only in one of the cases reported in the literature of other countries is cataract mentioned. *Intellect* appears to be distinctly dulled, sometimes to the extent of mental deficiency. *General weakness*, failure to thrive, and in one case, cyanosis, were responsible for the patients being taken to hospital. *Blood examinations* have revealed nothing of interest.

Radiographic appearances—In radiographs the *epiphyses* generally are stippled, as if ossifying from many separate centres, the appearance being suggestive of that produced by flicking paint from a brush on to a clean surface. The spots vary in size, but most of them are minute and usually discrete. They also vary considerably in number, and are not always more numerous in older than in younger children. There is evidence that in some cases the spots may become gradually smaller and fewer in number (Hunermann 1931, Hassler and Schallock 1940, and Jorup 1944). On the other hand they may show a tendency towards fusion, with the formation of a single, more normal, centre of ossification. Often they appear at an earlier date than that at which ossification normally begins in the epiphysis concerned, and they may appear too early by several years. For instance, multiple centres were seen at the upper end of the ulna in a number of cases, and in all these the olecranon epiphysis should not have been visible for some years. Abnormally early ossification, stippled in character, was also seen in the lower humeral epiphysis, the radial head, the floor of the acetabulum, the ischial tuberosity and the neck of the scapula. Occasionally the carpus, tarsus and patella also showed signs of premature ossification. Even though ossification in some epiphyses or in the carpus may proceed normally, without stippling, these centres may have appeared unusually early.

The epiphyses most frequently showing the typical stippled appearance are those of the upper and lower ends of the femur, upper end of the tibia, and upper end of the humerus. The lower end of the tibia, both ends of the fibula, the lower ends of the radius and ulna, and the bones of the hand, are much less frequently affected. This affection differs strikingly from bone dysplasias generally in so far as characteristic changes are often shown in the region of the elbow joint, multiple centres being found at the lower end of the humerus and in the radial head, as well as in the olecranon. In at least four cases the femoral condyles showed a curious appearance, the spots of ossification being arranged around the periphery in a curved line; in two of these the outer condyle only was outlined in this way, the inner showing just a few central spots. In a case with involvement of one lower limb, there was at sixteen months an irregular mottled centre for the lower femoral epiphysis with, in addition, a separate group of small discrete centres for the medial condyle; at nine years, this epiphysis and that for the adjacent tibial head, though both somewhat larger than the corresponding centres of the opposite leg, were approximately normal in outline and density.

In Lightwood's case (1930), more or less normal centres were present in the lower femoral epiphyses close to the metaphyses, with additional stippled centres nearer the articular surfaces of the condyles. The stippling at the ends of the long bones is inclined to be erratic, spots being sometimes seen where no part of an epiphysis should be found, and perhaps absent where ossification should have begun. It is often difficult to decide the correct allocation of the bony spots, particularly if there is contracture of the knee or elbow joints and the shadow of the proximal bone is foreshortened.

In at least two patients the proximal ends of the ribs were stippled, and this in spite of both being infants. In the same two patients the thyroid cartilage showed signs of ossification, and in one the hyoid was stippled. Apart from stippling in the acetabulum and ischium, already referred to, the pelvis, with one exception, was fairly normal in shape and appearance. Stippling has not been seen in the iliac crests. In two patients, aged four months and three weeks respectively, the symphysis showed a median dense vertical line of calcification, and in both wrists there was a single dense centre well to the inner side of the carpus. A similar curiously placed centre near the carpus was also seen in the first case reported by Bateman

(1936), but in this case two unstippled carpal bones were visible—the capitate and hamate Stippling of the vertebrae was apparent in several cases, and of the sacrum in four In at least two cases, each vertebral body was ossifying by two separate centres, one in front of the other one of these (Lightwood 1930) was examined histologically by Professor H A Harris (1933) In a case published by Hassler and Schallock (1940) only a single centre was present for each vertebral body, but stippling was seen in some of the intervertebral discs These authors also reported calcification in the tracheal rings, in the skin, and even in synovial membrane

The shafts of the femora and humeri, and occasionally of the tibiae, are decidedly short and thick, the ends being splayed to a marked degree with an irregular surface at the epiphysial line At the upper ends of the femur and humerus the enlarged metaphysis often terminates in an oblique surface of considerable extent, being bevelled off on the inner side In such cases it is difficult to visualise the cartilaginous epiphysis, and to identify the anatomical site of the dense spots correctly At the upper end of the femur, for instance, the position of the spots sometimes suggests that the greater trochanter is ossifying before the head of the bone The position of the femur in relation to the pelvis may suggest dislocation of the hip, this being recorded in at least three cases (Lightwood 1930, Hassler and Schallock 1940) In several, the upper end of the ulna seems to be unduly prominent, as if it were subluxated inwards in others, the lower end of this bone may be bevelled off on the outer side

The condition of the tarsus varies ossification may be entirely by stippled centres, or the talus and calcaneus may be normal and only the heel apophysis show marked stippling long before ossification begins normally In two cases this apophysis appeared in a lateral radiograph as a vertical line, a considerable distance behind the calcaneus In one case, with changes confined to one leg, the front and back parts of the talus, and the medial cuneiform, were stippled, while the calcaneus, navicular, cuboid, and the greater part of the talus, were of normal density Irregularity of the outline of the tarsal bones may be the only abnormality seen in the foot

In one typical case at the age of three weeks (Hilliard 1943), the base of the skull was abnormally dense, and the shafts of some of the long bones, notably the tibiae and the metacarpals, showed triangular dense areas towards each extremity, while the talus and calcaneus, the only two tarsal bones ossified, showed a circular line, slightly more dense than the remainder of the bone, similar to that sometimes seen in osteopetrosis and in chronic poisoning by certain chemicals

Progress—At present it is impossible to say what the ultimate condition of the epiphyses may be, because no late reports of a case showing generalised changes are available In the monomelic case already referred to, which was re-examined at the age of nine years, there was clear evidence of fusion of the discrete centres of ossification which had been present at an earlier age, and of general improvement in the appearance of the epiphyses However the ankle joint showed gross abnormality in the contour of the bones, and a narrowed and irregular joint space suggestive of arthritis The femoral head was enlarged and less convex than normal, and the femoral neck was short and wide

Early death—Half the patients are known to have died, all but one before reaching the age of twelve months The causes of death were infections involving the lungs or kidneys, and miliary tuberculosis, while in one case death occurred suddenly for no reason which was discovered

Pathology—Harris (1933) reported patchy mucoid degeneration and cystic spaces in the cartilaginous epiphyses, particularly near the articular surfaces In some places the areas of degeneration were invaded by blood vessels, and a core of fibrous tissue had formed In the vertebral bodies which ossified from two centres, there was failure of the usual orientation of cartilage cells, and of normal calcification and ossification Harris insists that the fundamental error is similar to that which he found in achondroplasia

Hassler and Schallock (1940) made an exhaustive study of a child with this disorder who died a few days after birth They found curious circumscribed, polymorphous deposits of chalk in the cartilage, and, near these, larger confluent areas of calcification In other parts, new bone formation was replacing the chalky areas They also found diminution of the zone of ossification between bone and cartilage at the epiphysial lines In places this zone had disappeared completely

Conradi (1914) illustrates star-like foci of calcification in the cartilage In the child reported by Lund (1942) who died at the age of four months, the muscles were found to be replaced largely by tough fibrous tissue which apparently accounted for stiffness of the joints In this case also, histological changes in the bones were said to resemble those of achondroplasia

Diagnosis—This must depend on radiographic examination Discrete stippling, as opposed to the mottling and epiphysial irregularity seen in dysplasia epiphysialis multiplex, and also sometimes in cretins, is quite distinctive If a case could be followed for a few years, and the spots of ossification were given time to fuse, the distinction would probably become more difficult In a doubtful case, the diagnosis is made easier if there is bilateral cataract

I wish to express my thanks to friends and colleagues who have supplied me with details of their cases Figs 12 and 15 are reproduced by courtesy of the British Journal of Surgery

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CASE 6—DYSPLASIA EPIPHYSIALIS PUNCTATA

(Fig 12) Child, aged one month, with congenital shortening of the right leg The child died at age of nine months

Fig 12

Case 6 Right lower limb showing typical stippling of most of the epiphyses and of the tarsal bones Note that there are two separate groups of ossific centres for the femoral condyles The tibial head is subluxated

CASE 7—DYSPLASIA EPIPHYSIALIS PUNCTATA

(Figs 13–16) Female child, aged two and a half years Parents normal Failed to develop normally from birth Mentally dull Double congenital cataract Marked bossing of skull Fontanelle closed Enlargement of epiphyses Beading of ribs Fingers have blunt, square extremities Limitation of movement of knees and elbows Wassermann negative Thyroid administration gave no improvement Gradually wasted, and died of pneumonia when aged three and a half years (Under Dr Eric Pritchard)

FIG 13

Case 7 Right leg showing typical appearances femoral shaft short, thick, and strong with metaphyses splayed and the epiphyses stippled Note the stippling in the ischial tuberosity as well as in the acetabular cup

FIG 14

Case 7 Pelvis and hips showing curious shape of the ilia, and, on each side, stippling of the acetabulum and upper extremity of the femur

FIG 15

Case 7 Left upper limb showing stippled epiphyses thick shafts of the long bones, premature ossification of the olecranon from many centres and marked bevelling on the inner side of the upper end of the humerus

FIG 16

Case 7 Feet showing irregular shape of the tarsal bones a little stippling in the heel, and premature ossification of the calcaneal apophyses

CASE 8—DYSPLASIA EPIPHYSIALIS PUNCTATA

(Figs 17–19) Girl, aged four months Very feeble Large head, distended veins, fontanelles widely open, nose depressed Limbs short, particularly the proximal segments Hips, knees, and elbows flexed and cannot be extended fully Feet "solid" Ulnar deviation of hands Wrists stiff Reflexes accentuated Blood chemistry normal Bilateral congenital cataract Died during a feed, for no discoverable reason (Under Dr W G Wylie Case reported by Dr E Lund, 1942, under another title)

FIG 17

Case 8 Pelvis and femora showing central linear ossification in the symphysis premature stippled ossification of the ischial tuberosities and of the acetabular floor, short thick femora (partly due to fore-shortening) and general stippling of the shapeless upper extremities

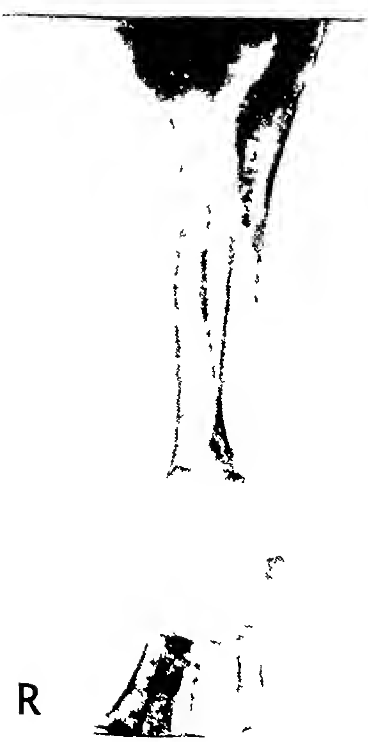

FIG 18

FIG 19

Case 8 Forearms showing the curious densely ossified spot to the inner side of each wrist joint Stippling in the region of the elbow including premature ossification in the radial head can just be seen

CASE 9—DYSPLASIA EPIPHYSIALIS PUNCTATA

(Figs 20 and 21) Male child, aged eleven months—only child of normal parents Limbs short, particularly the proximal segments Limitation of movement of hips Double congenital cataract Died within a few weeks of acute miliary tuberculosis (Under Dr R C Lightwood who published the case in 1930)

FIG 20

Case 9 Left upper limb showing short thick humerus with splayed metaphyses and bevelling on the inner side of the upper metaphysis and subluxation inwards of the ulna at the elbow, in addition to stippling at the shoulder and elbow

FIG 21

Case 9 Pelvis and femora showing typically short, thick femora with bevelled upper extremities and stippling of epiphyses at both ends Note the apparent dislocation of the hip joints and the premature ossification of the greater trochanters The lower femoral epiphyses show centres close to the metaphyses, in addition to stippling confined to the outer condyles

William John Little
1810-1894

William John Little

Orthopaedic surgery was one of the earliest specialities to emerge in England but its evolution was slow and gradual In our own day we have witnessed the growth of special branches of surgery from infancy to maturity, but it required more than a generation to bring orthopaedic surgery to full stature It started at the beginning of the Victorian era and, like many another movement, owed its inspiration to the leadership of one man, in this instance William John Little He was afflicted with a deformity of the foot due to infantile paralysis and, being compelled to contemplate his own disability and seek its cure in vain, he was aroused to the misery of thousands of cripples here in England He came from Norfolk farming stock who had lived for many generations in and about the village of Carbrook near Kimberley His father, John Little, migrated to London and eventually became proprietor and host of " The Red Lion " in Aldgate, a famous hostelry which was haunted by the memories of Dick Turpin who had often called there

William John Little, the third child of his parents, was born on August 7, 1810 His earliest recollection recalls a fragment of social history which can be read with appreciation to-day " The year 1814–15 was remarkable in my child-history The long war of over twenty years with France was terminated, but it left a heavy burden of debt upon our nation Scarcity of food was experienced by the poorer classes on and off during the war Bread riots occurred during the Autumn and Winter of 1814 I remember seeing the most riotous crowd of people being driven uninjured along the remarkably wide High Street of Whitechapel eastwards by a body of cavalry soldiers apparently from the City Afterwards, during the winter of 1814–15, the 10th Hussars were lodged in the district, their headquarters being at my father's house, the Red Lion Inn They occupied all above the ground floor which was not required by the family I must have been a highly privileged little person, often admitted into the drawing-room which was occupied as the day-room of the officers, some ten or a dozen in number The Colonel often took me on his knee I well remember that in the Spring of 1815 the Regiment's Route had come, and was informed of the road by which they were leaving via Essex to embark for the Continent at Harwich The Colonel (Clinton) kindly took me on his knee, patted me, condoled with my regret upon their leaving and told me that he hoped to return and see me again I expect he was a family man, and was thinking of his own family as he was again about to set out on Foreign Service The contest at Waterloo took place on the following 18th June The year 1814–15 was in many ways a remarkable one and forcibly impressed itself on my mind and memory It was also during the Spring of 1814 (February) after three months of frost that the Thames in London was solidly frozen up above and below London Bridge when a fair was held on the River My father took me to the fair and I believe that I remember the gingerbread stalls and the preparations for, if not the roasting of, an ox "

When he was four years old Little suffered from infantile paralysis The antero-external group of muscles of the left leg were completely paralysed, leading to contracture and talipes equinovarus His young school companions in England gave him the nickname " lame duck " and in France " canard boitu " He attended a day-school at Goodman's Fields and acquired knowledge of French, as well as of English grammar and arithmetic About this time he and his father went to Paris, spending two days on the sea-crossing Both arrived at Dieppe, prostrate with sea-sickness After two years at the day-school he spent some years at a school at St Margaret's, near Dover, and at the age of thirteen entered the celebrated Jesuit College of St Omer, near Calais Here he distinguished himself by winning, against native competitors, the prize for French composition He afterwards spoke highly of the management of the College, and of the instruction and kindness which he received, the Fathers made no attempt to convert the young protestant

On leaving St Omer he decided upon a medical career For two years he was apprenticed to James Sequeira, a surgeon-apothecary of Aldgate whose family became well known in the medical world In 1828 Little entered as a student at the London Hospital where Sir William Blizzard was then lecturing on Surgery He also attended classes at the Aldersgate School of Medicine, where Robert Grant of University College lectured on Anatomy and Thomas Hodgkin of St Thomas's lectured on Pathology In 1831 he qualified by obtaining the Licence of the Apothecaries Company and the next year received the diploma of Membership of the Royal College of Surgeons In 1832 the committee of the London Hospital decided to send Dr Frederick Cobb, one of their physicians, to investigate an outbreak of Asiatic cholera at Tyneside Dr Cobb took Little with him and both set out by coach, in wintry weather, for Newcastle

From the time he began to study medicine Little sought a means of curing, or at least minimising, the disability for which he had been obliged to wear a leg appliance His hopes were raised by reading in Cruveilhier's "Anatomie Pathologique," of Delpech's improved *method of dividing the tendo Achillis in a case of club foot He begged Sir Astley Cooper* and other surgeons to perform the operation upon his own tendon, but none would consent because of the risk of diffuse suppuration and sloughing Since Delpech did not repeat the operation it seems that he was not pleased with the result Little's hopes were, however, revived by reading in the "Archives Generales de Medicine" that Dr Louis Stromeyer of Hanover had proposed important modifications of Delpech's plan and treated two patients successfully Little decided to go to Germany and learn for himself, taking with him a letter of introduction from Robert Grant to Johannes Muller In 1835 and 1836 he visited Leyden, Leipzig, Dresden, and Berlin, and made contact with several distinguished surgeons and anatomists He found that there was no more enthusiasm for the operation in Germany than in England However, Professor Muller and Professor Froriep of Berlin considered that Stromeyer's operation was based on sound anatomical and surgical principles Thus encouraged, Little went to Hanover and placed himself under the care of Stromeyer who divided his tendo Achillis, gradually corrected the deformity of the foot, and gained a successful result Little was more than pleased with the treatment Stromeyer gave him the opportunity of performing subcutaneous tenotomy himself The operation of Delpech had been done through a one-inch incision on each side of the tendo Achillis, and it was therefore liable to infection On the other hand Stromeyer's operation was truly subcutaneous, performed through a single tiny puncture—the only method with any claim to safety in the pre-Listerian era Little returned to Berlin He showed his cured foot, and demonstrated Stromeyer's operation, to both Muller and Diffenbach and convinced them of the great advance initiated by this new procedure He impressed them so much that he was allowed to dissect many deformed foetuses in the Berlin museum An account of these researches, and of the treatment of talipes varus, including that of his own case, were embodied in a Latin thesis entitled "Symbolae ad Talipedem Varum Cognescendum" for which he was awarded the degree of Doctor of Medicine of Berlin

Little returned home and carried out the first subcutaneous tenotomy in London on February 20, 1837, the year that Queen Victoria came to the throne This was the beginning in England of a serious attempt to deal with deformity by operation and manipulation The treatment of club foot had been neglected, and Little threw himself with great ardour into the task of rousing the profession Patients quickly came his way, he gained experience, and in 1839 he published his treatise on "Club Foot and Analogous Distortions" He described in detail the varieties of talipes and their treatment by operation, manipulation, and splinting In this book the deformity "talipes cancaneus" was so named and described for the first time—"bearing the same relation to T valgus as T equinus bears to T varus" This classic was the first frankly orthopaedic work to be published in this country On July 3 the same year he was elected assistant physician to the London Hospital He had become a Licentiate

of the Royal College of Physicians He was also appointed Lecturer on Comparative Anatomy and Physiology, and later Lecturer on Medicine His position as a consulting physician who practised tenotomy was somewhat anomalous but he was strongly advised by friends and by his teacher, Dr Archibald Billing, that there was no impropriety in so doing Throughout his professional career he practised no less as a medical consultant than as an orthopaedic surgeon, but his combination of both may have influenced the delay of his election to the Fellowship of the Royal College of Physicians

The problem of the cripple had been present to his mind from boyhood, but it gathered force with increasing knowledge of the unhappy plight of thousands of cripples left to their fate He had found himself in possession of a remedy, and it became insistent in his mind that the remedy should be put to the service of the community He dreamt of an institution for the study and treatment of cripples, and to this project he applied all his energies After spending two years in collecting funds and finding a site, the Orthopaedic Infirmary was opened in 1840 in Bloomsbury Square Lord Chancellor Eldon was chairman This was the first hospital in Britain to be devoted solely to the study and treatment of disabilities of the limbs and spine and in which the word Orthopaedic was incorporated in its name It was something new, and it was an outward and visible sign that a special branch of surgery was emerging It attracted such public support that greater accommodation soon became necessary A large mansion on the north side of Hanover Square, formerly occupied by Earl St Vincent, the famous Admiral, was bought and altered to provide accommodation for fifty beds Patients were transferred from Bloomsbury On March 25, 1845, a Royal Charter of Incorporation was granted to the Infirmary, the name of which was changed to "The Royal Orthopaedic Hospital" Some years later two other hospitals were founded—the City Orthopaedic Hospital in Hatton Garden in 1851, and the National Orthopaedic Hospital in Great Portland Street in 1865 It is worth noting that at this last hospital, in 1892, Mrs Muirhead Little started the first hospital school of which there is any record She noted with misgiving how long-stay patients were deprived of education She started with part-time teachers, but the venture was so successful that a whole-time teaching staff was soon employed This was many years before the Board of Education began to consider the provision of special residential schools

Early in this century all three hospitals amalgamated, and in 1905 a new Royal Charter was granted, giving the combined hospitals the name of Royal National Orthopaedic Hospital The National Hospital in Great Portland Street was pulled down and a fine building with 200 beds was erected in its place The new hospital inherited a great tradition It was in the direct line of W J Little's foundation of 1840, and there were memories of distinguished men who played their part in forming that tradition, including Adams, Fisher, and Hughlings Jackson, to name but a few In 1922 the country branch at Stanmore was started It was developed continuously until the outbreak of the recent war when it became a sector base hospital Since the war, the hospital has had attached to it the Institute of Orthopaedics of the University of London for the training of post-graduates in orthopaedic surgery, the Board of Governors including representatives of the Royal College of Surgeons and the British Orthopaedic Association

After the establishment of his hospital, Little continued his clinical and pathological investigation of deformities In 1843 he published a monograph "On Ankylosis or Stiff Joints" This was a masterly summary of what was then known of the pathology of ankylosis He described the application of tenotomy, and he advocated gentle and gradual methods of correction He also began the teaching of orthopaedic surgery His lectures and notes were published in 1855—"Lectures on the Deformities of the Human Frame," in which he gave a full and accurate description of a hitherto unknown disease, affecting two brothers, together with autopsy findings He gave no name to the disease and his description of it escaped

notice But thirteen years later Duchenne described the same malady and called it pseudo-hypertrophic muscular paralysis

On October 2, 1861, before the Obstetrical Society of London, he read a paper "On the influence of abnormal parturition, difficult labour, premature birth, and asphyxia neonatorum on the mental and physical condition of the child, especially in relation to deformities" In his first book, and in Lectures on the Deformities of the Human Frame, he had already described infants with spastic paralysis, but in this contribution he dealt extensively with a study of sixty-three cases This paper, published in 1862, in the third volume of Transactions of the Obstetrical Society, aroused widespread interest, and spastic paralysis of infants became known as Little's disease He wrote many other papers and delivered many addresses For Timothy Holmes' "System of Surgery" he wrote on orthopaedic surgery In 1868 he published a monograph "Spinal weakness and Spinal curvature" In 1881, when the International Medical Congress was held in London, he contributed two papers, one on club foot and the other on genu valgum His last monograph, "Medical and Surgical Aspects of In-knee (Genu Valgum)," was published in 1882 in conjunction with his son, E Muirhead Little

He visited Canada and the United States in 1878, saw McDonnell at McGill Medical School and the Montreal General Hospital, and at Quebec saw the Governor-General, Lord Dufferin, who was one of his old patients In New York he met Detmold, born in Hanover, a pupil of Stromeyer, who introduced subcutaneous tenotomy to America Detmold was surgeon to Bellevue Hospital, and he recognised in Little a kindred spirit He introduced him not only to Bellevue, but to many other hospitals in the city Little also met Judson with whom he discussed spinal curvature This American tour was the outstanding feature of the last years of his active practice He retired in 1884 and thereafter lived at Ryarsh, near West Malling, Kent He lived long enough to see orthopaedic surgery established in England and to receive the honour due to him as a pioneer He was elected honorary member of the Medical Societies of Florence, Dresden, and Constantinople He died at Ryarsh, after a few days' illness, on July 7, 1894

In his younger days Little was handsome He was tall, with brown hair, grey eyes, and regular features, but early baldness gave him a venerable appearance By nature he was reserved and retiring, but he held firmly to his convictions In old age increasing deafness did not alter his kindly disposition He married Elizabeth, the daughter of Thomas Roff Tamplin, of Lewes, Sussex Two of their sons became surgeons Louis Stromeyer Little was surgeon to the London Hospital until he resigned and went to practice in China Ernest Muirhead Little became honorary surgeon to the Royal National Orthopaedic Hospital and was elected first President of the British Orthopaedic Association

William John Little did three things He introduced subcutaneous tenotomy to England —a landmark in the cure of cripples He wrote the first important book on orthopaedic surgery—a publication which stimulated scientific investigation He established the first orthopaedic hospital for the study and treatment of disabilities of the limbs and spine He was indeed the founder of British orthopaedic surgery

ARTHUR ROCYN JONES

I wish to express my thanks to Admiral Sir Charles Little, G C B G B E and to Mr Neil Little of Geneva for their kindness in placing at my disposal family papers relating to their grandfather

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GEORGE WILLIAM CALLENDER

JESSIE DOBSON, LONDON, ENGLAND

Recorder, Royal College of Surgeons of England

George William Callender was born at Clifton, Gloucestershire, on June 24, 1830 His father was a member of an old Scottish family, though his immediate ancestors had settled in Barbados His early education was gained at "The Bishop's College," Bristol, and if it had been left to his choice he would have joined the Navy, but many members of the family

FIG 1

Portrait of Callender reproduced from a scrapbook of photographs and caricatures of the staff and students of St Bartholomew s Hospital by kind permission of the librarian of the hospital

had entered the medical profession and in due course he studied medicine with his uncle, Dr Lancaster of Clifton At first he disliked his occupation but he persevered, especially after the death of his mother in 1848 when he felt it a duty to set a good example to younger brothers The next year he entered St Bartholomew's Hospital Medical School He was

noted for neatness and accuracy, pleasing manners, and a well-dressed appearance After gaining many honours and prizes he was admitted as a member of the Royal College of Surgeons in 1852 and appointed house surgeon to St Bartholomew's Hospital In July 1854 he became Registrar and Demonstrator of Morbid Anatomy and thereafter never lost his interest in this subject In the Transactions of the Royal Society of 1869 (p 163) he published a paper entitled "The Formation and Growth of the Bones of the Human Face" This, with other scientific anatomical works, secured his election as a Fellow of the Royal Society in 1871 In the same year, on the resignation of Sir James Paget, he was elected surgeon to St Bartholomew's Hospital and examiner in surgery to the University of Cambridge He practised in Queen Anne Street and held the appointments of surgeon to the Charterhouse, and professor of anatomy at the College of Surgeons He claimed that septicaemia was almost unknown in his wards and, though he did not refer to Lister's theories of asepsis, the principle of his treatment was, in fact, a modified Listerism His last publication, on "The Avoidance of Pain," was delivered to the Section on Surgery at the Bath meeting of the British Medical Association Having gained a prominent place in the esteem of his colleagues, and being recognised as one who represented the highest merits of British surgery, he died at the age of forty-nine years, and was buried at Kensal Green Cemetery on October 29, 1879

To Callender belongs the distinction of solving the problem of the fate of the premaxilla in man Many anatomists had speculated on this subject Galen, Vesalius, Sylvius (Dubois), Colombus, Falloppius, Riolan, Tyson, Nesbitt, Albinus, Daubenton, Vicq d'Azyr, Camper, Goethe, Soemmering and other nineteenth century anatomists had made contradictory contributions to the literature It was due to the careful investigations of Callender that the truth emerged Of the development of the maxilla, he wrote in Philosophical Transactions, 1869-70, Vol 159, pages 164 to 169

'If in a foetus nine-tenths of an inch long the superficial parts are removed that portion which forms the superior maxilla is seen to occupy the position and to have the shape of the future bone, the orbital palatal and alveolar parts being defined whilst two considerable projections indicate the position of the *nasal* and of the *incisor* processes ' (P 164)

'In a foetus 2 3 the bone (superior maxilla) presents the following appearances Taking a point below the infraorbital notch as a centre three processes are traced from it The *nasal* forms a thin plate having the permanent shape of the process, but the ridge for the turbinate bone the vertical thickening of its lower nasal surface and the nasal groove are wanting From its base a smooth plate of bone passes forward the centre bit as it were of the incisor portion chief part of the roof of which it ultimately forms and to this hitherto I believe, unrecognised portion the name of *incisor process* may be rightly given ' (P 165)

The outstanding feature of this very accurate description is the recognition of the nasal and incisor processes of the maxilla usurping the site occupied by the separate premaxilla (intermaxillary) in lower animals He defined the typical mammalian premaxillae thus

These bones though their appearances vary in different mammals have amongst these animals certain common features 1) The line of articulation with the superior maxilla is in front of the canine socket when the latter is present when absent the relation of the suture to the maxilla virtually remains unaltered 2) The premaxilla as it is more correctly named for these animals is prolonged superiorly to a point which ascends to a varying distance or is cut short abruptly In any case, whatever be the length of the posterior margin a groove is found in the anterior edge of the superior maxilla and into this the wedge shaped margin broad or narrow (sometimes almost incisive as in the sheep), of the premaxilla is inserted and is thus embraced as it were by the front border of the upper jaw 3) The premaxillae carry the incisor teeth when present 4) They articulate in the middle line sometimes leaving a notch in front for a continuation forward of the septum 5) They form more or less of the front of the palate of the boundary of the incisive foramina and of the complete or partial septum which separates them (Pp 166-167)

Having thus established the identity of the premaxilla in the typical mammal, Callender then defined its limits in the developing human embryo

' Passing to an examination of the human foetus, it is evident from the shape and direction of the incisor process (which is best examined in a foetus 4 3 being then easily detached from the intermaxilla) that it passes across the anterior boundary of the nostril as the latter is continued forward to the middle of the

lip This boundary above is partly covered by the nasal process below the palatal portion of the superior maxilla ends abruptly behind it, and between the two it is that the incisor process crosses, and indents the orifice of the nostril

In a foetus 2 3 the intermaxilla consists of deposits of bone about the posterior edge of the incisor process which subsequently grow down to form the plate of bone on the inner side of the middle incisor socket and the posterior wall of the incisor sockets below and internal to the course of the incisor branches of the dental nerve The front wall of the middle and lateral incisor sockets is continuous, as previously stated, with the plate of bone which covers in the canine notch

'In a foetus 4 3 the intermaxilla is completely formed and may be traced as a distinct bone It consists of the parts already described, which are continued backwards to form the front of the palate filling up the notch between the incisor and palatal processes, and of a narrow portion which ascends and fits by a convex surface into the groove of the nasal process, ending above at the ridge for the turbinate bone, part of which ridge it forms ' (Fig 2)

FIG 2

Left superior maxilla from human foetus (4 3 inches long) *a*) inner wall of antrum continuous with the palate *b*) incisor process *c*) intermaxillary bone

"In a foetus 9 inches long either intermaxillary bone is in great part fused with its corresponding upper maxilla The anterior edge of its nasal process has united to the nasal process of the maxilla and its horizontal portion is inseparably attached to the upper surface of the incisor process but the outline of the bone is preserved by a fissure which is traced along its posterior margin from the middle of the nasal process of the maxilla and which deepens as it reaches the palate through which it extends, often permanently ' (pp 167–168 See Fig 3)

Finally, Callender sums up his conclusions as follows

"The preceding observations account for the absence of all trace of the human intermaxillary bone on the facial aspect of the upper jaw in the adult whilst the permanent fissure through the palate and on the inner side of the nasal process are equally explained The bone, in fact, is shut off from the face by the nasal and incisor processes of the superior maxilla Distinctly outlined" (Fig 2) "at the close of the fourth month it is joined to the superior maxilla during the latter part of the fifth or beginning of the sixth month its nasal process as it may conveniently be termed is buried in that of the upper jaw, the apex assisting to form a permanent ridge for articulation with the inferior turbinate bone In a foetus 1 5 I notice a slight cleft in the nasal process of the superior maxilla corresponding with the top of the groove on its inner surface but I have never seen anything like an approach to the formation of a distinct anterior plate of bone such as forms part of the premaxillae of mammals ' (pp 168–169)

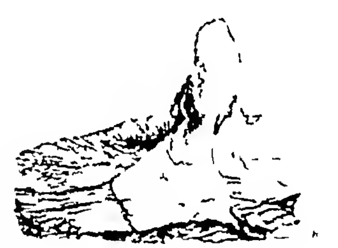


FIG 3

Left superior maxilla from human foetus (9 inches long) *c*) intermaxillary bone completely united in front to maxilla, *g*) canal which extends for a short distance beneath the intermaxilla *h*) plates of bone belonging to the intermaxilla, which assist in bounding the incisor sockets

Sir William Flower in 1870, in the first edition of his "Osteology of the Mammalia" (p 130), wrote "The premaxilla is a distinct bone in the human foetus but is covered on its external or facial aspect by a process of the maxilla which extends over it towards the mid-line and becomes completely fused with it before birth, so that no trace of the maxillo-premaxillary suture is ever seen on the outer side of the face On the inner and palatal aspect of the bones the suture is always evident at birth and can often be traced even in adult skulls See G W Callender, 'On the formation and growth of the bones of the Human face' Phil Trans, 1869, p 163" In 1882 Sir George Thane incorporated Callender's teaching into the standard English text-book of human anatomy (Quain's Anatomy, 9th edition, Vol I, pp 72–73) More recently, Edward Fawcett (1924) included Callender's views in his paper entitled "The development of the bones around the mouth" which was published by the Dental Board of the United Kingdom

IN MEMORIAM

THOMAS GWYNNE MAITLAND, M A , B Sc , M D , D Phil
1875-1948

Few surgeons in this country, and perhaps fewer in other countries, know how great a part was played by Thomas Gwynne Maitland in developing the orthopaedic and fracture services of Great Britain To many it will be a surprise to learn that he, more than any other, was responsible for the creation of fracture and accident services in every important hospital in this country under the direction of orthopaedic departments

Through his responsibility as medical superintendent of the Cunard White Star Company he quickly learned of the crippling disasters which might arise from fractures and other injuries He was incensed by the medico-legal conflicts that were fought in County Courts, and he recognised the stupidity of settling claims for disability where there should never have been disability at all He began, nearly twenty years ago, by arranging a meeting in the Liverpool Medical Institution which was addressed by Robert Jones, Rowley Bristow, Harry Platt, Thomas McMurray, Harold Moore, Watson-Jones, and others He arranged dinners on board the "Carinthia," the "Mauretania," the "Georgic," the "Brittanic," and the "Queen Mary" It may seem a far cry from the pleasures of hospitable dinners on board Atlantic steamships to the labours of developing fracture services in England But this was his technique He was a superb host—charming, entertaining, cheerful and lovable Everyone who met in his company felt happy, he planned carefully that those who were most capab of developing accident and fracture services should meet and learn to know each other, ar he made them happy in their meeting and in their knowing

Thus it was, in consequence of a deliberately planned though apparently care-fre stimulus, that in 1935 the British Medical Association appointed a Fracture Committe

which published an astonishing and startling report Within very few months a Government Committee was appointed to implement the recommendations His Majesty the King honoured by his presence a dinner which was attended by leading industrialists The successful creation of fracture and accident services in every industrial area of the country was assured Simultaneously, this great pioneer took no less energetic steps by which to improve the medical services of the Merchant Navy, to introduce medical health services to every industry, and to establish an Association of Industrial Medical Officers In these tasks he was no less successful Yet the one name never heard, never recognised, and never applauded, was that of Thomas Gwynne Maitland

The writer of this appreciation once took the liberty, in a text-book on fractures, of acknowledging in few and simple words the debt that was owed to Maitland Only one person was furious, and he was very furious indeed—Maitland himself "How can I go on with my work," he said, "if you put me in the limelight?" We may perhaps learn from such modesty Much important work is best done without limelight

Gwynne Maitland graduated in medicine in Edinburgh He was a doctor of philosophy of the University of Manchester, editor of the Manchester Medical School Gazette, lecturer on physiology in the University of Wales, lecturer in psychology at the Birmingham Medical Institute, director of the typhus colony in Serbia during the first world war, and author of "Examination of the Basis of Personality" But to those who knew him best he was more than a doctor, a physiologist, and a psychologist, he was more than a pioneer who devoted much of his life to the relief of suffering and disability, he was more than the founder of deck tennis who established most of its rules, he was more than a friend, a companion, and a charming and delightful host He was a man—a very great man—to whom we could take our problems and our difficulties Only to talk to him was to solve the problem, only to meet him was to gain the stimulus, only to stay with him was to acquire the inspiration We suffer his loss very greatly

R W-J

JOHN BERNARD REID, M Ch Orth (Liverpool), F R C S (Edin)
1900-1948

The totally unexpected death of J B Reid at an early age is a severe blow to the orthopaedic services of the North-East coast of England, and particularly to the Middlesbrough district, where his activities were concentrated Born in Lockerbie, Reid served in the 1914–18 War He then qualified as a pharmacist, although his great desire was to practise medicine As pharmacist and photographer he was able to save enough money to enter the medical school of the University of St Andrews in 1924 His University career was remarkable He gained every prize open to him except that of Neurology, and then held a resident hospital appointment for six months He became a District Surgeon in Southern Rhodesia, but he felt that he was inadequately trained to carry out the surgical work which had always been his aim Resigning from his appointment in Rhodesia he returned to this country, quickly gained the Fellowship of the Royal College of Surgeons in Edinburgh, and then trained in Liverpool and gained the Degree of Master of Orthopaedic Surgery He served as orthopaedic registrar at the Northern Hospital, Liverpool, for two years when he was elected orthopaedic surgeon to the North Ormesby Hospital, Middlesbrough Here was a new field which he could organise and develop and he never spared himself, but worked constantly for the recognition of his chosen subject, and for the advancement of the hospital services He was so keen and enthusiastic a worker that in the thirteen crowded years of his professional life he was also appointed honorary orthopaedic surgeon to five other hospitals He was recognised as an expert in both gardening and music and for many years was President and Chairman of the Cleveland Scots Society Unfortunately his writings on surgical subjects were far too few, but his cheerfulness, his sterling surgical judgment, and his willingness to help were appreciated by colleagues and patients alike

T P McM

PROCEEDINGS AND REPORTS OF UNIVERSITIES, COLLEGES, COUNCILS AND ASSOCIATIONS

GREAT BRITAIN

BRITISH ORTHOPAEDIC ASSOCIATION—ANNUAL MEETING, 1948

The Annual Meeting of the British Orthopaedic Association was held in Belfast on Thursday, Frida and Saturday October 21–23 under the presidency of Mr S Alan S Malkin (Nottingham) It is mo than twenty years since the Association last met in Belfast and this visit was a tribute to Mr S T Irwi whose loyalty to the Association is widely respected The meeting was a brilliant success Never befo did young members of the Association present their contributions with greater ability Almo without exception they spoke without script or notes and, although in speaking extemporaneously the added to the anguish of mind which is suffered by every worth-while speaker, they greatly enhanced th clarity of their delivery They did well and the Editor of this Journal would add his congratulatio to those offered in the course of the meeting by the President and Mr Osmond-Clarke

Mr Irwin was supported ably by Mr R J W Withers Mr Martin Mr A Chance Mr Harold Roger and all of Mr Irwin s colleagues associates and juniors, who were responsible for the organisation at th Royal Victoria Hospital of one of the best clinical demonstrations we have ever enjoyed It was unfortunat that we had only hours and not days to study the many scores of cases which were presented wit such thorough documentation

Sir David Lindsay Keir, Vice-Chancellor of Queen s University who has served for many years a chairman of the Northern Ireland Council for Orthopaedic Development * gave a reception in Queen University and with Lady Keir he attended the reception arranged at the City Hall by the Lord Mayo of Belfast and Lady Neill which was enjoyed by more than two hundred and fifty fellows and member of the Association

Annual Dinner of the Association—The Annual Dinner was held in the Great Hall of Queen s University and the toast of His Excellency the Governor of Northern Ireland, Vice-Admiral the Earl Granville was proposed by the president of the Association In responding to the toast of the British Orthopaedic Association which had been proposed by *Dr Montgomery* chairman of the Northern Ireland Hospitals Authority *Sir Harry Platt* said that it was the privilege of the aged to indulge in nostalgia He recalled the memory of Robert Jones in whom all personal rivalries were resolved and said that we were still under the influence—the stabilising influence—of the Liverpool school which was so powerful an antidote to impulsive surgery and emotional therapy ' *Sir David Lindsay Keir* said how unique an experience it was for him to be a guest within his own College He recalled the advances in surgery and fracture treatment that had contributed so important a part to the history of Queen s Medical School over the last hundred years *The Rt Hon William Grant* Minister of Health in a witty speech said that in Northern Ireland an agreed bill for the new National Health Service was presented to the House and yet in the course of debate five hundred amendments were accepted I often wonder he added ' what would have happened if we had not had an agreed bill' In recalling the spirit of Ulster and the close and happy relationships that exist between Northern Ireland and Great Britain the Minister of Health concluded ' It is not for nothing that we in Northern Ireland count ourselves as part of you We are members of a team together '

The Painful Shoulder—A discussion of the Painful Shoulder was opened by *Professor G Perkins* (London) He reviewed the underlying pathology and in his own inimitable style succeeded in debunking ' certain beliefs *Mr V H Ellis* (London) after referring to extrinsic causes such as coronary disease discussed supraspinatus tendon injuries He said that excessive pull in the straight supraspinatus for instance a sudden muscle contraction with the shoulder fixed in abduction, would avulse a fragment from the greater tuberosity, whereas a similar pull when the limb was lowered and the tendon curved over the humeral head would cause rupture of the tendon Pathological changes might alter this rule Loss of supraspinatus function might be reflex with rapid spontaneous recovery or it might be due to a complete tear Complete tears were sometimes revealed by arthrography in which the passage of radio-opaque fluid through the capsule, and often into the subdeltoid bursa might be demonstrated In suture of the tendon removal of the acromion made operation easier, and recovery quicker *Mr W C Somerville-Large* (Dublin) recalled the value of anaesthesia in discriminating between muscle spasm and structural change causing restriction of movement He believed that adhesions, if present, were capsular In diagnosis, the site

* See Report of the Northern Ireland Orthopaedic Scheme Journal of Bone Surgery 1948 30-B 39, written by Mrs Doreen McConnell who played so important a part in organising this meeting in Belfas

of pain was of little help but accurate localisation of tenderness was valuable Attention should be paid to the severity of tenderness, and the question as to whether the site of tenderness changed when the limb was rotated Radiographs should be taken in at least four projections—with the joint fully rotated medially in the mid position in full lateral rotation, and in lateral rotation with body twist Changes in profile of the greater and lesser tuberosities were described

Mr R J W Withers (Belfast) had investigated one hundred shoulders in which pain was of intrinsic origin In twelve pain for a few days after injury was ascribed to supraspinatus rupture, twenty-seven had a full range of movement but with a painful arc at mid-elevation, and sixty-one presented pain with much stiffness which was ascribed to capsulitis There seemed to be two stages of capsulitis in the first stage of "irritative" capsulitis, stiffness was due to spasm and it disappeared under anaesthesia, in the later stage of "adhesive" capsulitis stiffness persisted under anaesthesia In irritative capsulitis there had been pain for an average period of seven weeks it was diffuse, and worse at night After rest in a sling for a few weeks active exercises were encouraged Heat seemed to be of no value Full painless movement was restored in from three to four months The forty-one patients who showed evidence of adhesive capsulitis had not attended until symptoms had been present for about eight months, in these cases pain was less severe and less diffuse and it was usually referred to the deltoid insertion About 20 degrees of shoulder movement was preserved Manipulation was the primary treatment free movement usually developing after lateral rotation had been regained After further exercise, recovery was usually complete in a period which varied from a few weeks to four months but follow up examination nearly always revealed persistent crepitus In three of the forty-one cases treatment failed Treatment of the painful shoulder could be summed up in the words "time and patience"

Mr F A Simmonds (Pyrford) considered that in injuries of the supraspinatus cuff the full cycle of changes might occupy from six months to two years usually about one year In twenty-one cases a follow-up of more than three years had shown that even after that time some patients still had pain, weakness or stiffness Biopsy revealed degenerative changes in the tendinous cuff with chronic inflammatory reaction, the interior of the joint appearing normal In treatment, the use of a sling with exercises practised within the painless range, such as pendulum exercises were useful but heat was of doubtful value *Mr Stewart M Harrison* (Birmingham) reviewed one hundred cases of minor injury of the shoulder causing pain and stiffness He had found radiographic evidence of abnormality in the greater tuberosity of the humerus in thirty In these patients the average duration of treatment had been forty-nine days, whereas patients whose injured shoulders were stiff and painful but in whom there was no radiographic evidence of abnormality in the tuberosity, attended for an average period of eighteen days Moreover, late follow-up examination showed that symptoms were still present in all patients whose shoulder joints showed these radiographic changes whereas the other seventy cases had no residual symptoms There was pathological as well as radiographic evidence of a peripheral articular focus of degeneration

Mr J R Armstrong (London) had found that about three-quarters of all patients who attended an orthopaedic department with the supraspinatus syndrome recovered spontaneously For those patients who did not recover provided that the range of movement was not limited he advised excision of the acromion In about one hundred operations he had found that a variety of lesions gave rise to similar symptoms supraspinatus tendonitis with increased vascularity and swelling supraspinatus tears mostly in older subjects, and comprising either true tears or incomplete avulsions calcification in a roughened supraspinatus tendon and subdeltoid bursitis with acute inflammation or chronic thickening associated with a little fluid and sometimes loose bodies It was important to excise the whole acromion *Mr J Tulloch Brown* (Killearn) had found that infiltration with 10 c c of 1 per cent procaine was valuable as a diagnostic aid in distinguishing tendonitis from tendon injury in the supraspinatus syndrome Loss of movement due to spasm could be differentiated easily from that due to structural change If, under the influence of procaine infiltration, free active movement was regained conservative treatment was indicated If despite anaesthesia active movement was still limited the evidence of tendon rupture was clear and operation was necessary

Mr G Blundell Jones (Exeter) described acute cases of supraspinatus calcification with sudden pyrexial onset and short course in which there was early and spontaneous disappearance of the calcium deposit This possibility should be borne in mind when estimating the value of various forms of treatment such as injection and aspiration Many such cases recovered despite the treatment, and not because of it *Mr W E Tucker* (London) said that focal sepsis and gout should be considered in some cases He agreed with the importance of rest in the acute stage

Arthrodesis of the Hip Joint—*Mr H A Brittain* (Norwich) showed a film of his operation of ischio-femoral arthrodesis *Mr H H Langston* (Alton) said that he had performed thirty of these operations, without sciatic nerve injury but with failure of fusion in five cases There had been perforation of the obturator foramen by the graft in two cases and sequestration of the graft in one *Mr W B Foley* (Oxford) advocated open operation through a posterior incision reflecting gluteus maximus upwards and inwards He had performed ischio-femoral arthrodesis under direct vision in seventeen cases of tuberculous arthritis and two of osteoarthritis Bone fusion had occurred rapidly in all but one case *Mr* *Mc*

(Norwich) described and illustrated a method of ilio-femoral arthrodesis of the osteoarthritic hip with a lag screw in combination with cancellous grafting of the lateral part of the hip joint by which it was hoped to accelerate convalescence and permit earlier weight-bearing *Mr John Charnley* (Manchester) discussed the principles of arthrodesis of the osteoarthritic hip joint and the possibilities of utilising compression forces in accelerating fusion *Sir Reginald Watson-Jones* (London) said that whatever value there might or might not be in the compression advocated by Mr McKee and Mr Charnley it was still true to-day, as it always had been, that new bone could not mature in less than three to four months We should be cautious in accepting these claims for acceleration No matter what screws nails or grafts were used, external protection by means of plaster for three to four months was imperative

Cadaveric Bone Grafts—*Mr W Sayle Creer* (Manchester) reported fourteen fractures of the shafts of long bones treated by grafts of boiled cadaveric bone In seven out of eight cases of ununited fracture of the forearm bones union took place in an average period of twenty-three weeks after grafting

Peripheral Nerve Tumours—*Professor J H Biggart* (Belfast introduced by Mr S T Irwin) reviewed one hundred and fifty-four peripheral nerve tumours comprising thirty-four neurinomas (Schwannomas) one hundred and ten neurofibromas and ten neurosarcomas *Neurinomas* had occurred in patients aged thirty to fifty years mostly in the head and neck and the upper limbs Unlike neurofibromas, they were never found in the dermis At operation they appeared to be encapsulated, and some did not recur Some underwent mucoid degeneration Palisade arrangement of nuclei gave a characteristic histological appearance the structure was sometimes syncytial *Neurofibromas* affected chiefly the limbs, especially the lower limb and seldom the head Superficial neurofibromas were often epidermal In deep nerves they were often part of a widespread involvement and possibly this accounted for the frequency of recurrence which happened in approximately 30 per cent of cases The histological appearance of infiltration of surrounding tissues should not be mistaken for malignancy Their origin was uncertain *Neurosarcomas* usually affected flexor surfaces and deep nerves most commonly the sciatic nerve The histology resembled that of fibrosarcoma but the cells were less pointed Professor Biggart ascribed the three types of tumour to the neurilemma cell

A "Lively" Splint—*Mr Norman Capener* (Exeter) showed a double shoulder abduction splint in which the arm pieces were linked with the trunk piece by spring wire, to allow supported movement during convalescence from poliomyelitis

Excision of the Trapezium for Osteoarthritis of the First Carpo-metacarpal Joint—*Mr W H Gervis* (Tunbridge Wells) said that he had performed this operation on eighteen occasions In two cases arthritis was of the rheumatoid type in sixteen there was degenerative arthritis of the carpo-metacarpal joint A dorsal incision avoiding the radial artery gave access to the bone Care was taken to ensure complete excision and to avoid damage to flexor carpi radialis Immediate active exercises were encouraged In rheumatoid cases the results were poor In all others the results were excellent there was good movement good power and no pain One patient was able to milk cows for many hours a day

Results of Treatment of Kienböck's Disease—*Mr A Dornan* (Sheffield) reported forty-seven cases of Kienböck s disease observed during the last ten years Forty-two had been re-examined for late review He had not been able to confirm any association between this disorder and shortness of the ulna Conservative treatment in twenty-seven cases gave these results excellent (no complaints, full work without difficulty)—nine good (discomfort, but full work without loss of time)—eight fair (unable to do heavy work)—seven poor (no improvement)—three Excision of the lunate bone had been performed in fifteen cases nine after failure of conservative treatment with these results excellent—seven good—four fair—four In summary, thirty-seven of the forty-two patients were doing heavy work many at the coal face

Conservative Treatment as compared with Operative Treatment of Ununited Fractures of the Carpal Scaphoid Bone—*Mr Goronwy E Thomas* (Liverpool) had investigated eighty cases of fracture of the carpal scaphoid bone treated at various hospitals by various surgeons more than three year previously for non-union—fifty-two with operation and twenty-eight without The operations had included excision of the scaphoid (twenty-four cases) excision of the proximal row of the carpus (six) bone graft (nine) arthrodesis of the wrist joint (ten) and sundry operations (three) Among the nine cases of grafting there was only one good result—in a case of non-union of six months duration only one patient returned to heavy work Of the ten cases of arthrodesis of the wrist joint only two were clinically and radiographically successful one was doing heavy work bone fusion had often failed Twenty-four of the twenty-eight patients treated conservatively returned to heavy work seven of the fifty-two patients treated by operation returned to heavy work It was conceded that the operations had been carried out by various surgeons in various centres *Mr W Sayle Creer* (Manchester) and *Mr H Osmond-Clarke* (London) said that the two series of cases were not comparable They believed that no deductions could be drawn from them

Regeneration of the Articular Surface of the Femoral Head after Cup Arthroplasty—*Mr Noel J Smith* (Peterborough) showed a specimen from a woman who had died from a cardiac complication eight weeks after vitallium cup arthroplasty for osteoarthritis The denuded surface of the femoral head had become covered with a smooth fibrous cap, at the periphery the fibres were less tightly packed and fibro cartilage cells were present

The Capener Nail Plate in Trochanteric Fractures of the Femur—*Mr E Mervyn Evans* (Birmingham) classified trochanteric fractures as stable or unstable in accordance with the degree of injury to the cortex of the calcar femorale If cortical bone was intact the fracture was stable if it was not intact there was a tendency to coxa vara whether the fracture was nailed or not An investigation had been made of one hundred and one fractures treated conservatively—mostly by weight-traction with Thomas splint The average age of the patients was sixty-two years there were fifteen deaths the average stay in hospital was fifteen weeks and coxa vara occurred in eighteen Among twenty-two patients treated by Capener nail fixation there were no deaths and the average stay in hospital was seven weeks, coxa vara occurred in four and union was not yet complete in three The advantages claimed for operation were greater comfort and mobility for the patient, lower mortality shorter stay in hospital, and possibly greater stability of the fracture

Pseudarthrosis for Ankylosis and Arthritis of the Hip—*Mr J S Batchelor* (London) described removal of the femoral head and neck from fifty hips of forty-four patients, with the addition in thirty-two operations of angled osteotomy of the upper end of the femur in order to promote stability The osteotomy might be performed at the primary operation with plating of the fragments or three to five weeks later through a posterior or postero-lateral approach Light traction was applied after operation through an upper tibial transfixion pin Walking was resumed after eight to ten weeks The operation had been undertaken for osteoarthritis ankylosing spondylitis fracture dislocation ununited fracture of the femoral neck ankylosis from old acute arthritis and chronic suppurative arthritis The results were classified as satisfactory—thirty-nine unsatisfactory—ten death—one Unsatisfactory results were due to instability—three pain—three lack of co operation—two, restricted movement—one and non-union of the osteotomy—one

Gastric changes in Rheumatoid Arthritis—*Professor H W Rodgers* (Belfast introduced by Mr S T Irwin) had carried out gastroscopy in patients with rheumatoid arthritis In the active stage the stomach lining was hyperaemic and it produced an excess of acid Later in the chronic stage of the disease the lining was atrophic and inactive like a spent endocrine gland It was suggested that the anaemia of the acute stage might be secondary to the febrile state but that later anaemia might be due to nutritional iron deficiency

Intramedullary Nailing of the Shaft of the Femur—*Mr A Chance* (Dublin) reviewed twenty-one fractures treated by open insertion of a Kuntscher nail The most suitable fractures for intramedullary nailing were transverse interlocking fractures of the middle third where the medullary cavity was cylindrical The result was prejudiced if there was a loose fragment The normal curvature of the femur was an advantage because it allowed more lengthy contact between nail and cortex The best length of nail was one which was shorter by 4 cm than the distance between the greater trochanter and the lateral femoral condyle of the uninjured thigh It was important that the nail should fit the medullary lumen snugly at its narrowest part The patient was allowed up with crutches about three and a half weeks after operation but weight-bearing was not permitted before union was evident There was little difficulty in regaining a satisfactory range of knee movement *Dr P G K Bentzon* (Denmark) emphasized the seriousness of infection if it arose as a complication of this operation

Aseptic Necrosis of the Femoral Head—*Mr E N Wardle* (Liverpool) had studied aseptic necrosis of the femoral head radiographically in cases of fracture osteochondritis juvenilis and traumatic dislocation Among forty-six cases of fracture of the femoral neck there was aseptic necrosis in fourteen, seven with union and seven without He advocated that nailing of these fractures should be accompanied by grafting In his first thirty cases he had used a tibial cortical graft but in the last sixteen he had used iliac cancellous chips rammed firmly into the drill-hole

The Presidential Address on The Scientific Approach to Orthopaedic Surgery ' delivered by Mr S Alan S Malkin is published in this issue of the Journal Other papers read at the meeting which are published in this or in the previous number included Ischio-femoral Arthrodesis—H A Brittain Premature Epiphysial Fusion at the Knee Joint in Tuberculous Disease of the Hip—W Parke Spontaneous Ischaemic Necrosis of Muscle—J Rowland Hughes Posterior Dislocation of the Shoulder—C K Warrick

Robert Jones Golf Cup

A competition for the Robert Jones Golf Cup was played at the Royal County Down Club Newcastle, after the Belfast meeting of the British Orthopaedic Association There can be no more beautiful golf course in Ireland to its immediate south the mountains of Mourne sweep down to the sea to its east

is the wild Irish Sea and to the west, typical Irish countryside The course itself was in very fine condition Mr S T Irwin M P, entertained the twenty-one competitors to an excellent lunch at the club-house and at the end of the day presented a replica of the Robert Jones Cup to the winner, Mr Maitland Smith of Doncaster who returned 83 − 7 = 76 the exact bogey score for this championship course Mr J V Todd of Newcastle upon Tyne playing from scratch, returned 78 and was placed second His second nine holes were played in the remarkably low score of 34 against the bogey of 37 Next year the Robert Jones Cup will be contested during the spring meeting at Nottingham

HONOURS TO ORTHOPAEDIC SURGEONS

Medal of the Academie de Chirurgie (Prix Laborie) to Mr J Trueta (London)—Mr Trueta, honorary member of the British Orthopaedic Association since 1942, who was made a D Sc Honoris Causa by the University of Oxford in 1943 and an Honorary Fellow of the Royal College of Surgeons of Canada in 1947 for his contribution to the treatment of war wounds has now been awarded the Medal of the French Academie de Chirurgie (Prix Laborie)—a distinction seldom given to foreign surgeons The Prix Laborie was founded in 1868 and among those who have been honoured with it are many of the great surgeons of France such as *Broca, Mouchet Lenormand Chevassu Leriche* and Iselin On November 10, 1948 the President of the Academie de Chirurgie presented the medal to Mr Trueta in the presence of a crowded assembly which included some of the most outstanding surgeons of France, among them Professors Rene Leriche Louis Bazy and Merle d Aubigne

Mr Trueta addressed the Assembly on the renal circulation and its pathology with particular reference to the research which he and his colleagues have carried out at the Nuffield Institute in Oxford, and which is now being continued by him at the Royal Veterinary College, London It is of interest to note that work on the renal circulation was initiated by Mr Trueta in 1941 with the purpose of finding an explanation for the renal failure of ' crush syndrome and that an orthopaedic surgeon, interested in blood circulation in the tissues of the limbs has thus made an important contribution in interpreting some of the complex problems of kidney pathology

Knighthood conferred on Mr H Ernest Griffiths (London)—In the New Year s Honours List, 1949 it is announced that Mr H Ernest Griffiths of the Albert Dock Seamen s Hospital, London is to become a Knight Bachelor the honour being conferred for his work in rehabilitation of the disabled

REHABILITATION AND RESETTLEMENT OF THE DISABLED IN GREAT BRITAIN

In October and November 1948 a course was arranged by the British Council the Ministry of Labour and National Service and the Ministry of Health to demonstrate to visiting surgeons and social workers from many countries the steps taken in Great Britain to aid rehabilitation and resettlement of the disabled The visitors were welcomed by General Sir Ronald Adam, Bt Chairman of the British Council The course was introduced by Dr Harold Balme of the Ministry of Health who spoke on ' The Prevention Limitation and After-Care of Disability and Mr R Gomme of the Ministry of Labour and National Service who explained the work of that Ministry in resettlement of the disabled

Visits were paid to St Helier s Hospital Carshalton where important pioneer work has been done by Dr F Cooksey, to the Vauxhall Motor Works Rehabilitation Centre, Luton where under the guidance of Dr A Thompson and Mr L R Plewes many hundreds of injured men and women have had function restored by treatment in a special workshop of the factory to the Harefield County Hospital where Dr W McPhail supervises the rehabilitation of patients with tuberculosis of the chest to Roffey Park Surrey which is one of the pioneer rehabilitation centres for industrial neurosis to the National Institute for the Blind in Great Portland Street London, where the newly blinded are taught to be independent, to Papworth Village Settlement, near Cambridge, now under the direction of Dr R Trail which has long been renowned for the treatment, employment and resettlement of tuberculous patients to St Margaret s School Croydon where Dr J H Crosland demonstrated the physical treatment of cerebral diplegia in children to Stoke Mandeville Hospital where Dr L Guttman has done such magnificent work in the training and resettlement of patients with spinal injury and permanent paraplegia, to Egham where the first residential industrial rehabilitation centre of the Ministry of Labour was established during the war to Farnham Park Recuperative Centre, Slough where Dr Austin Eagger has developed ambulance posts, dressing stations central clinics, gymnasiums and resettlement centres to Queen Elizabeth's Training College for the Disabled Leatherhead, which is world-famous for its pioneer work in teaching trades to the seriously crippled, and to the Albert Dock Seamen's Hospital where Mr H E Griffiths has developed a gymnasium for out-patients

At Queen Mary's (Roehampton) Hospital Mr St J D Buxton and Mr *Langdale Kelham* discussed problems of amputation, limb-fitting and the re-training of patients with amputations At an Industrial

Neurosis Unit at Sutton Dr Maxwell Jones demonstrated a Placement Conference One day was spent with Mr E A Nicoll at Berry Hill Miners Rehabilitation Centre, Mansfield, near Nottingham—a centre which was the pioneer of a complete series of residential and non-residential rehabilitation centres throughout the country for the final treatment of serious fractures and other injuries in miners At the Birmingham Accident Hospital and Rehabilitation Centre, Mr W Gissane demonstrated every stage of treatment from primary emergency measures to final rehabilitation in the gymnasium Dr Donald Stewart showed the terminal stages of rehabilitation in one of the workshops of the Austin Motor Company—the first industrial concern in this country to devote a special workshop to the rehabilitation of disabled men The problems of placement of the disabled in suitable employment the work of Disablement Resettlement Officers of the Ministry of Labour the activities of a Government Training Centre and of an Industrial Rehabilitation Unit were also demonstrated in Birmingham

The final problem of resettlement—that of securing employment for those who are so seriously disabled that they cannot compete in the open labour market, and cannot be engaged by any ordinary employer was explained by Air Commodore Venn, executive-director of the Disabled Persons Corporation whose ' Remploy factories are being developed in all parts of the country

This course was arranged primarily with the object of demonstrating to our visitors the action taken in Great Britain to assist disabled persons to restore themselves to the normal duties of citizenship We hope that they gained from what they saw and heard and from their observations it seems that they did But whether they did or not this review of our activity was stimulating to some, even in this country who for many years may have felt that they were ploughing a lone furrow We are impatient, and it is right that we should be but meanwhile we may gain solace from the fact that great progress has indeed been made

ROYAL COLLEGE OF SURGEONS OF ENGLAND

Robert Jones Memorial Lecture—The Robert Jones Memorial Lecture of the Royal College of Surgeons of England was delivered by Sir Reginald Watson-Jones, December 9 1948 on ' The Reactions of Bone to Metal ' the attendance establishing a record for the statutory lectures of the College The lecturer said that the four causes of bone resorption in the region of metal were 1) thermal due to burning of bone by high speed drills 2) electro-chemical, due to ionisation of metals or alloys 3) bacteriological due to lighting of quiescent infection or to faulty operative technique, 4) physiological due to the effects of compression of metal plates or screws insufficiently protected by external support It had long been known that tight wires or bands caused bone resorption It was now well recognised that nail fixation alone was insufficient for arthrodesis of the hip—the nail became loose and all cases failed Similarly modern experiments in replacement of the femoral head by a metal prosthesis must fail it was impossible to secure permanent fixation of metal to bone if bone was compressed, it would absorb Even the slight compressing effect of normal blood pressure on the periosteal surface of a bone caused resorption—as in aneurismal erosion of the spine Still less pressure even less than capillary pressure, was enough to cause bone resorption when the orthodontist moved a tooth The very slight compression force of a cystic meniscus caused absorption of the tibia

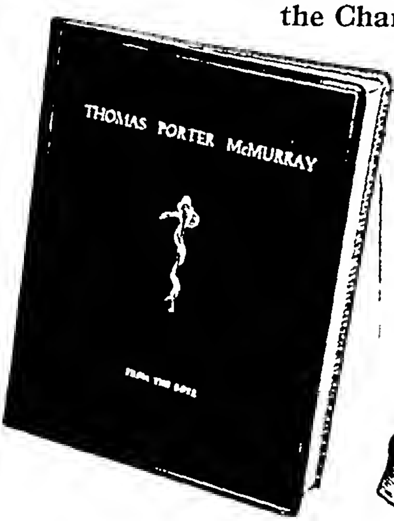
Since it was well established that bone reacted to compression by resorption was it not wise to review again the modern tendency of fracture treatment which urged the use of lag screws slotted plates transfixion pins with clamps and other devices by which to impact and compress bones? It might be that osteoid had greater resistance to the harmful effects of compression than adult bone but until there was further evidence it should be assumed that compression clamps assisted only in so far as they promoted immobilisation and prevented shearing strains Certainly there was no evidence that the compression of early weight-bearing promoted union of fractures the evidence was in the opposite direction—union was delayed

Normal protection from the adverse influence of compression lay in the avascular articular cartilage of joint surfaces and the trabecular arrangement of bones which distributed compression forces Even these did not suffice if compression was sufficient and was sustained—as for example in the deformed foot of the Chinese girl and the wedged vertebra of adolescent scoliosis This had a bearing on the treatment of congenital dislocation of the hip joint in which despite reconstruction of the acetabular roof the distribution of weight-bearing could be so disordered by anteversion of the femoral neck that even a well-established acetabular roof underwent absorption before puberty during the years of most rapid growth

Robert Jones Dining Club—The Robert Jones Dining Club met in London on the evening of the Robert Jones Memorial Lecture and the lecturer was toasted

Hunterian Oration and Hunterian Lectures—The Hunterian Oration will be delivered in the College on February 14 by Mr H S Souttar on John Hunter—The Observer Hunterian lectures in February will include Diastasis of the Tibio-Fibular Syndesmosis by Professor J G Bonnin and " The Treatment of Residual Disability following Injuries of the Peripheral Nerves of the Upper Extremity " by Professor Robert Roaf

Dinner to Professor T P McMurray on his Retirement from the Chair of Orthopaedic Surgery in Liverpool



On October 20 1948 a dinner was held in the Exchange Hotel Liverpool in honour of Professor T P McMurray which gave to more than fifty of his old students an opportunity to thank him and wish him well on his retirement from the chair of orthopaedic surgery in the University of Liverpool In short speeches Bryan McFarland and Goronwy Thomas who respectively had been McMurray s first and last assistants paid tribute to the greatness of his character Mr F R Tucker of Winnipeg Canada presented a leather-bound volume inscribed on vellum which embodied the signatures and portraits of men who have passed through the Liverpool School of orthopaedic surgery during the last twenty-five years The feeling of those present and of the many who sent greetings from far across the seas was expressed in an address which prefaced the collection

1 Presentation Volume
2 Title Page 3 Portrait

" To Professor THOMAS PORTER McMURRAY—This book is signed and presented by your old students as a symbol of their respect and affection and to record for ever the debt which they and their country owe to you By your teaching and by your skill you have enhanced a great tradition This is now our treasured heritage and by our deeds we will preserve it '

McMurray was deeply moved and in his reply he extended to " The Boys ' near and far a sincere invitation to come and visit him any time at Ystrad Cottage Denbigh He carefully spelt the word ' Ystrad " Incidents of humour, courage and skill were recounted in a series of spontaneous speeches which left no doubt as to the place which is occupied and held by Tom McMurray in the hearts of former students

DEGREE OF MASTER OF ORTHOPAEDIC SURGERY, UNIVERSITY OF LIVERPOOL

In December 1948 post-graduates, who have studied orthopaedic surgery in Liverpool and allied centres during the last fifteen months, sat for the University degree of Master of Orthopaedic Surgery Mr Bryan McFarland, Director of Orthopaedic Studies, was the internal examiner, and the external examiners were Professor G Perkins (London) and Mr R I Stirling (Edinburgh) Twenty-two candidates were successful

Baker G W	Edinburgh, Scotland
Browne R F	Birkenhead, England
Covell, N A G	Liverpool, England
Dawson, R H	Whangarei, New Zealand
Denness T	Liverpool, England
Duraiswami P K	Madras, India
Gallagher M J	Brisbane, Australia
Hughes, J R	Liverpool, England
Hugh-Smith W A	Sydney, Australia
McSweeney, A F	Brisbane, Australia
Minnaar A B D	Paarl, South Africa
Mirkin L	Port Elizabeth, South Africa
Mukopadhaya B	India
O Driscoll, R F	Nelson England
Patton, W H G	Nairobi, Kenya
Robertson J H G	Bulawayo, Southern Rhodesia
Saha A K	Calcutta India
Shatwell G L	Liverpool England
Slack, C C	Liverpool England
Smyth E A	Royal Army Medical Corps
Sutherland I D	North Berwick, Scotland
Virgin, W J	Toronto, Canada

ROYAL SOCIETY OF MEDICINE, AUTUMN 1948

At a meeting of the Orthopaedic Section of the Royal Society of Medicine held on Tuesday, December 7 1948 *Mr A S Blundell Bankart* (London) showed a film of his operation for recurrent anterior dislocation of the shoulder joint

Treatment of Secondary Deposits in Bone—*Mr E W Riches* (London) read a paper on the treatment of secondary deposits in bone from prostatic carcinoma He recommended treatment by stilboestrol, the dosage being controlled by serial estimations of blood alkaline phosphatase He showed records which demonstrated fall in the blood phosphatase level under treatment and gave grounds for much greater optimism than that which was generally to be expected from treatment by other methods *Mr Anthony Green* (London) read a short paper on the general treatment of secondary deposits in bone dealing principally with the use of high-voltage radiation therapy He said that treatment should always be preceded by biopsy and needle biopsy with a special instrument was useful The instrument was demonstrated but in subsequent discussion the shortcomings of needle biopsy for the diagnosis of tumours in bone were stressed

Electrical Reactions of Muscle in Poliomyelitis—*Mr Ian McKenzie* (Newcastle upon Tyne) gave a preliminary review of his work The electrical reactions in affected muscle were altered characteristically and this alteration might be demonstrated by plotting a time-intensity curve '—the same curve for practical purposes as that obtained by the Ritchie-Sneath method for determining altered chronaxia in denervated muscle Deviations of the curve from the normal were helpful in providing an earlier prognosis of the degree of recovery which might be expected in paralysed muscle The optimal time for the investigation was four weeks after the onset of illness An interesting discussion ensued during which the president mentioned his association with this work and stated his opinion that the investigation was likely to prove valuable but that further inquiry was necessary before its true value could be estimated

Internal Rotation Dislocation of the Shoulder—*Mr L S Michaelis* (London) reported a case in which the shoulder joint was locked in full adduction and internal rotation The radiographic appearances were deceptive Attempted manipulative reduction was unsuccessful and open reduction was performed In the course of discussion only one member said that he had seen a similar case this too had presented difficulties in diagnosis and treatment open reduction being necessary It was pointed out that difficulty

in radiographic diagnosis should be overcome by examining the position of the medial epicondyle of the humerus which was an accurate index of the direction of the humeral head

Generalised Diseases of Bone in the Adult—At a meeting of the Section of Medicine held in the Spring of 1948 *Dr E F Scowen* (London) discussed the effects of sex hormones and adrenal cortex on osteogenesis *Dr J F Brailsford* (Birmingham) outlined his classification of generalised bone diseases, and *Sir Thomas Fairbank* (London) described unusual cases

Prevention of Accidents—At a meeting of the Section of Epidemiology and State Medicine held on November 1, 1948 *Mr W Gissane* (Birmingham) discussed the incidence and severity of domestic and industrial accidents and said that there was no room for complacency Structural arrangements in hospitals modern equipment, and team-work which covered not only emergency treatment but also after-treatment was not always as well developed as it should be There had been definite progress Many hospitals now had well organised accident departments Crippling deformities which reduced industrial efficiency were less common than they had been The effect of treatment was greatly enhanced when patients received rehabilitation specially designed to fit them for their particular work The prevention of accidents might be difficult—but prevention of the crippling results of accident could be tackled forthwith

In analysing 736 accident cases treated in hospital *Dr Leonard Colebrook* (Birmingham) said that 504 occurred in the home and 232 in industry The fatality of home accidents was six times greater than that of industrial accidents and the length of stay in hospital was 25 per cent longer due largely to the more serious consequences of burns and scalds sustained by children and old people One third of all patients sustaining burns in their homes were epileptics The importance of prompt admission to hospital of all cases of burns whether due to hot liquids coal fires electric or gas fires hot baths, or inflammable liquids, was emphasized Preliminary emergency treatment nearly always complicated the problem

REGIONAL ORTHOPAEDIC CLINICAL MEETINGS IN GREAT BRITAIN

Manchester Hospital Region

During 1948 orthopaedic surgeons of the Manchester Hospital Region held three very successful clinical meetings The first of a preliminary nature was held at the Manchester Royal Infirmary on April 3, 1948 *Sir Harry Platt* emphasized the need for close co operation between practising orthopaedic surgeons of the region and the value of informal meetings for the discussion of clinical and administrative problems It was decided that not less than three meetings should be held each year—in February July and early December Chief assistants registrars and house-officers working in the various orthopaedic departments were to be invited to attend and take part in the clinical discussions *Mr John Charnley* (Manchester) and *Mr R S Garden* (Preston) were appointed conveners There was a short demonstration of interesting cases by junior members of the Orthopaedic Department of the Manchester Royal Infirmary The cases included cyst of the medial meniscus two femoral shaft fractures treated by Kuntscher nail depressed fracture of the external tibial condyle in a young man treated by open reduction complete rupture of the brachial artery accompanying dislocation of the elbow joint in an adult gross prognathism treated by Kostecka s resection of the ascending rami of the mandible Photographs illustrating operative technique were demonstrated including the removal of disc prolapse, leg lengthening and arthrodesis of the knee by compression There was a museum demonstration of bone tumours

The Second Clinical Meeting was held on July 16 1948 at the Wrightington Hospital for Surgical Tuberculosis Wigan *Mr J Dobson* (medical superintendent) presented a series of cases of tuberculosis of the hip joint treated by ilio-femoral arthrodesis cases illustrating secondary lesions after primary bone lesions examples of gross shortening of the leg from premature epiphysial arrest at the knee in tuberculous disease of the hip joint and a case of late paraplegia treated by conservative methods with recovery *Mr H C Palin* (Burnley) showed radiographs of a case of displaced lower femoral epiphysis reduced successfully by open operation *Mr A Ronald* (Barrow-in-Furness) presented radiographs of fractures of the lower end of the tibia and lower end of the humerus due to falls from a height *Mr I D Kitchin* (Lancaster) presented a case of bilateral stress fractures of the femoral neck in an old lady *Mr D Ll Griffiths* (Manchester) showed an interesting series of arteriograms and phlebograms in various orthopaedic conditions

The Third Clinical Meeting was held at the Preston Royal Infirmary on December 3 It was well attended and having started at 10 45 a m it ended only at 6 p m with one hour's break for luncheon Nine short papers aroused much interest and lively discussion *Mr R S Garden* (Preston) demonstrated cases of acute haematogenous osteomyelitis treated by massive dosage of penicillin combined with early metaphysial decompression by drilling—the method recently advocated by Tucker and Hollenberg (Lancet 1948 1, 7) All cases healed rapidly without sinus formation or sequestration The treatment of fractures of the calcaneus by means of a walking plaster was demonstrated In this apparatus the walking cas

acted as a below-knee walking splint and it left the foot free, and capable of movement, though protected from weight bearing The treatment of fractures of the upper end of the tibia involving the knee joint by early movement was illustrated In all these tibial fractures in elderly patients there was an excellent range of painless movement after a comparatively short period of disability

Blood Supply to the Femoral Head—*Mr F R Tucker* (Liverpool) demonstrated specimens in which the blood supply to the femoral head had been revealed by injection of opaque masses Convincing evidence was presented that the ligamentum teres carried a significant blood supply in the adult The danger of destroying this blood supply during nailing of the femoral neck, if the point of the nail was allowed to reach the fovea, was stressed These anatomical studies suggested that internal fixation by multiple wires might produce less obliteration of essential vascular supply

Radio-ulnar Synostosis—*Mr I D Kitchin* (Lancaster) demonstrated a child with bilateral synostosis in extreme pronation, treated by resection of the upper end of the radius There had been striking improvement in the function of the hand, and on one side a slight range of rotatory movement had been regained He also demonstrated a case of bilateral Madelung s deformity with an excellent result after resection of the lower end of the ulna

Tight Tendo Achillis—*Mr W Sayle Creer* (Manchester) presented a film The relation between the everted and pronated foot and the tight tendo Achillis, was emphasized Methods of testing for shortness of the tendo Achillis were demonstrated and an instructive working model showed how tightness of the tendon could make the foot break at the mid-tarsal point by dorsiflexion while walking Examples of relief by elongation of the tendon were shown The film was commended as an example of skilful medical photography

The Healing of Fractures—*Mr John Charnley* (Manchester) presented histological sections He contrasted the appearance of profuse callus in a fracture of the femoral shaft sustained by a patient who died on the twenty eighth day with the appearance of pseudarthrosis of the ulna at six months The role of ensheathing callus was discussed The observation was made that in pseudarthrosis the essential fault appeared to be failure of the ensheathing callus to bridge the gap These sections suggested that pseudarthrosis was no more than a local phenomenon

Congenital Dislocation of the Hip Joint—*Mr S M Milner* (Manchester) discussed treatment He favoured gradual reduction without trauma by means of an abduction frame with leg irons which could be abducted to 90 degrees Interest centred on the small number of cases in which this method failed In discussion *Sir Harry Platt* referred to cases in which apparently perfect reduction was followed by subluxation and conversely reductions which initially appeared to be doubtful but later resulted in hips with perfect function The role of anteversion of the femoral neck, and of open reduction in relation to the interposition of soft parts, was discussed

Fracture-dislocation of the Lumbar Spine—*Mr C H Cullen* (Leigh) described treatment by internal fixation He used two metal plates bolted on each side of the spinous processes extending from two spines above the lesion to two below He indicated the value of this method in cases of paraplegia Experience in coal-mine injuries made him sure that it was the procedure of choice He operated at once under local anaesthesia and found no difficulty in reducing gross deformities by elevating the " kidney rest of the operating table and manipulating the fracture by bone forceps applied to the spinous processes Loose fragments of bone were often removed After internal fixation nursing was simple and the comfort of patients despite paralysis was in striking contrast with the miserable state of those treated in plaster beds Several cases of remarkable recovery from profound paraplegia were described

Legg-Calvé-Perthes' Disease—*Mr F C Dwyer* (Wigan) described his experience of ambulatory treatment in the Thomas patten-ended caliper *Mr C E Dransfield* gave a demonstration of appliances for leg and foot deformities which he had made in conjunction with a local instrument maker A heavy aluminium insert to the shoe was used for the treatment of the pronated foot with metatarsal callosities The concealment of gross degrees of leg shortening by special boots carrying an extension platform was particularly impressive

Radiographs of interesting cases were demonstrated—a case of perilunar mid-carpal dislocation in a child of eight (*Mr A Ronald*) a case of Calve's osteochondritis of the spine in a child of eight and one of Pott s disease of the fifth lumbar vertebra originally diagnosed as pyogenic osteomyelitis because staphylococci were obtained in pure culture from the abscess at the first aspiration (*Mr J Dobson*) a reversed Monteggia fracture (*Mr I D Kitchin*), a case of osteomalacia in a woman aged twenty-eight years (*Mr R W Agnew*) a bilateral fracture of the mandible through the wisdom teeth due to a blow at a point of the jaw in a patient who previously had incomplete occlusion at the incisors (*Mr H C Palin*) a case of premature fusion of the lower femoral and upper tibial epiphysis from unknown causes (*Mr D Cranna*)

Future Meetings—It is proposed to hold three meetings of the Manchester Hospital Region in 1949—in Manchester in February at the Ethel Hedley Hospital Windermere in July and in Blackburn in December

The South-West Orthopaedic Club

A meeting of the South-West Orthopaedic Club was held on October 2, 1948 at Winford Orthopaedic Hospital near Bristol *Mr H Chitty*, the chairman, regretted the death since the previous meeting of Mr Charles Kennedy of Plymouth the first chairman of the Club and a pioneer of orthopaedic surgery in the South-West

Prolapse of the Intervertebral Disc—*Mr K H Pridie* (Bristol) read a short paper on the indications for operation in prolapse of the intervertebral disc He advised against operation in the quiescent phase when there was no limitation of straight leg raising A spinal graft was seldom necessary He did not believe that radiographic examination gave much assistance in diagnosis Myelography was definitely harmful

Manipulation of Joints—*Mr J Bastow* (Bath) discussed the indications for manipulation of joints the chief of which were pain limitation of movement and deformity of joints He emphasized the importance of full investigation before embarking on manipulative treatment which often led to disaster Manipulation without anaesthesia was sometimes useful particularly in lesions of the muscular system

Compound Palmar Ganglion—*Mr D M Jones* (Bristol) reviewed the etiology pathology and treatment of compound palmar ganglion and demonstrated four cases treated by operation

Demonstrations—*Miss M Forrester-Brown* (Bath) demonstrated the well-known hip splint she has devised for early cases of congenital dislocation of the hip joint She also showed the splint she used during the convalescent stage of tuberculous disease of the hip joint *Mr A J Watkin and Mr Bailey* (Winford) demonstrated various types of apparatus used at the Winford Orthopaedic Hospital including the Cullen turning frame for recumbent patients in plaster and a perspex radiographic cassette holder and frame for use during the operation for nailing a fractured neck of the femur A simplified apparatus for the application of Russell traction was demonstrated for the treatment of fracture of the shaft of the femur

Clinical cases were shown at the afternoon session by Mr K H Pridie Mr A L Eyre-Brook and Mr D M Jones

BRITISH ASSOCIATION OF PLASTIC SURGEONS

Clinical Congress, 1948—The British Association of Plastic Surgeons held its Summer Congress on September 16 17, 18 at Oxford and Stoke Mandeville under the presidency of *Professor T P Kilner* The meeting was attended by ninety delegates including members and visitors from America Belgium, Denmark Ireland Norway Sweden and South America

Dr Sumner L Koch (Chicago) the guest of honour addressed the Association on the Surgery of the Hand He had found that healing was more certain since the application of antiseptics had been abandoned Ordinary soft white soap was used to prepare the operative field the afternoon before operation and again by an assistant, on the operating table He used an inflatable arm-cuff as a tourniquet and was prepared to leave this on for as long as three and a half hours No sign of paralysis has yet been seen in any patient The cuff was deflated at the end of the operation to allow the ligation of large vessels and it was then reinflated until the final bandage had been applied

Suture of Severed Flexor Tendons of the Digits—*Dr Koch* said that he would not suture tendons divided within the digital sheath because the blood supply was so poor He preferred to use a transplanted tendon from the dorsum of the foot passing this round the base of the distal phalanx Fine silk was used for suture material in preference to any form of wire He had no personal experience of wire but had not been impressed with the results he had seen Tendon grafts to fingers were never undertaken until all joints were mobile For uniting divided nerves he advised the finest cataract silk on eyeless needles in the form of simple interrupted sutures The hands and fingers were splinted in full flexion for three weeks modified splinting to prevent full extension was continued for a further period The results of nerve suture carried out more than two years after injury were poor

Decubitus Ulcers in Paraplegic Patients—*Mr R J V Battle* (London) said that free grafts were of no value Carefully planned local flaps were the solution to this problem but operations should not be undertaken unless the patient was in good condition for at best healing tended to be delayed

SCOTLAND

Appointment of Mr Walter Mercer as Professor of Orthopaedic Surgery in the University of Edinburgh—The Court of the University of Edinburgh has appointed Mr Walter Mercer to the recently established George Harrison Chair of Orthopaedic Surgery, which carries with it the responsibilities of Director of Orthopaedics for the South-Eastern Region of Scotland Professor Mercer is fifty-seven years of age He was trained in Edinburgh and graduated at the University of Edinburgh in 1912 In 1915 he w

commissioned and served as a regimental medical officer to the King's Own Scottish Borderers and Royal Scots Fusiliers and later in base hospitals in France and Italy In 1918 he was appointed to the surgical staff of the Edinburgh War Hospital, Bangour, under Sir Harold Stiles In 1920 he was elected clinical tutor to Mr J W Dowden in the Royal Infirmary, and the next year was made a Fellow of the Royal College of Surgeons of Edinburgh In 1925 he was appointed to the staff of the Royal Infirmary where he served in the Department of Clinical Surgery in the wards of Sir John Fraser, until his appointment to full charge of wards in 1943 At the outbreak of the recent war he served as consultant surgeon in orthopaedics at Larbert Base Hospital, and surgeon to the thoracic unit at Bangour Base Hospital

The objectives of the new Professor and Director of Orthopaedics will be to co ordinate and extend existing orthopaedic services of the Region and to organise undergraduate and post-graduate instruction with a view to the establishment of an Edinburgh School of Orthopaedics In a recent press report we read that ' Mr Mercer s new appointments will not occupy him full time but we take leave to doubt the accuracy of this observation His reputation as a general surgeon is international his interest in the surgery of the chest and heart and his very special interest in orthopaedic surgery is widely known and the industry with which he has prepared three successive editions of his text-book Orthopaedic Surgery is acknowledged We are quite certain that Professor Mercer will apply the whole of his energies to the task for which he is so well fitted It is a task which will demand all of his great resources

Mr Walter Mercer recently appointed Professor of Orthopaedic Surgery in the University of Edinburgh

North-East Region—The North-East Region of Scotland, which is based on the two central hospitals of Aberdeen—the Infirmary and the Hospital for Sick Children with forty-five beds for orthopaedic cases and the base hospital at Stracathro with two hundred beds is now served by peripheral orthopaedic clinics for adults and children at Elgin, Huntly Keith, Banff Fraserburgh, Peterhead, and Stonehaven A new orthopaedic department under the direction of *Mr A M Rennie* Lecturer in Orthopaedics to the University of Aberdeen has recently been opened at the Infirmary with plaster room waiting room almoner s office and two consulting rooms each with two dressing rooms and lavatory A feature of the new building is the construction with glass-bricks which permit excellent lighting despite the necessity for construction between two high buildings which would otherwise shut out much of the light

Scottish Surgical Paediatric Club—The first meeting of the recently formed Paediatric Club was held in Glasgow on December 17–18 and was attended by twenty-seven members representing Aberdeen Dundee, Edinburgh, Glasgow, and Inverness A dinner was held in the Royal Faculty of Physicians and Surgeons on the evening of December 17 A very full programme was arranged at the Royal Hospital for Sick Children Glasgow In the morning four papers were read and discussed and in the afternoon there were clinical and pathological demonstrations The next meeting will be held in Aberdeen in May 1949 Orthopaedic surgeons in Scotland, whose practice is concerned with children are invited to join the club

Scottish Council for the Care of Spastics—A special school for the care of children with spastic paralysis has just been opened in Edinburgh by the Scottish Council for the Care of Spastics The house which has been converted for this use was bought recently by the Scottish Branch of the British Red Cross Society

AUSTRALIA

Arthur Sims Commonwealth Travelling Professorship—On the recommendation of the Presidents of the Royal Australasian College of Surgeons the Royal College of Surgeons of England and the Royal College of Physicians Sir Reginald Watson-Jones has been appointed Arthur Sims Commonwealth Travelling Professor for 1950 A tour of Australia and New Zealand is being arranged and the Commonwealth Professor will attend the twenty-third annual general meeting of the Royal Australasian College in Adelaide It is hoped also to arrange a visit to Canada and, if possible, to the surgical centres of the Colonies of Africa

THE COLONIES

Little is known of the remarkable progress which is being made in orthopaedic surgery in the Colonies of the British Commonwealth We have invited from orthopaedic surgeons in Kenya Nigeria and Mauritius an account of their activities To these pioneers of surgery it must sometimes seem that their work is not recognised and it is true that few are in a position to know how great is their task But no matter how great their problems may be they should not be discouraged We are aware of their difficulties

and we are aware of the faithful sense of responsibility with which their difficulties are being met Great progress is being made, for which all responsible surgeons of the English-speaking world are grateful We expect from these surgeons many important contributions to our Journal, and meanwhile, in offering congratulations on their achievement, we acknowledge the privilege of being able to report their activities

Orthopaedic Centre, Nairobi, Kenya

Mr W H Kirkaldy-Willis tells us that his orthopaedic centre in Nairobi, Kenya has now been running for about six years It was started for the benefit of African pensioners who had been discharged from the Forces Since that time it has developed to include orthopaedic in-patient and out-patient treatment for all races The possibility is now being considered that this might become the orthopaedic centre for the three main territories of East Africa—Kenya Uganda, and Tanganyika

In the hospital wards and rehabilitation centre there are about 120 beds, but very often there are many more patients in the African wards than is warranted by the number of beds that are available The new hospital buildings with about 900 beds, will be completed in the near future The European staff includes one surgeon, two physiotherapists one orthopaedic technician and one apprentice In the workshops there are three Indian artisans The rest of the staff is African an African surgeon African masseurs and African assistants in the wards plaster room theatre, and workshops

Fig 1

Exercises in the gymnasium of the Nairobi Hospital which may become the orthopaedic centre not only for Kenya but also Uganda and Tanganyika

With certain differences, the types of case are much the same as in Great Britain There are very many fractures, most of them resulting from motor accidents Ununited and malunited fractures are sent from all over the Colony Old unreduced dislocations of the hip and elbow joints are often seen Osteomyelitis is very common usually it is seen in the later stages with the shafts of long bones affected more often than epiphysial areas Brucellosis of bones and joints is by no means rare Cases of bone and joint tuberculosis occupy almost one-half of the beds but accompanying chest lesions are seldom seen Disabilities of the foot—pes planus, hallux valgus and so on are rare possibly because few Africans wear shoes

In the rehabilitation centre, which is next door to the hospital there is a well-equipped physiotherapy department, a workshop where all appliances from walking calipers to artificial limbs are made, and handicrafts and occupational therapy unit Long-term patients both men and women do knitting and toy making Some patients carry on spinning in their homes after discharge from hospital bringing the wool for sale at three to six-monthly intervals and thus making possible late review of their condition

The handicrafts department is self supporting and each patient is able to earn money while in hospital, and even after discharge

Routine "follow up" of patients is not yet arranged but it is hoped shortly to have the services of a well-qualified African assistant who will build up a "follow-up" department make arrangements for patients to return for examination at regular intervals, and maintain contact with them and with Welfare Officers so that the standard of living, particularly of tuberculous patients, may be raised It is hoped that this venture may lead to the development of "after care" clinics in the African Reserves

The theatre team though overworked is good It is well versed in "no touch" technique The standard of nursing in the wards is still low there is much room for improvement Training facilities are poor, but it is hoped that there will be more adequate training for male and female nurses in the very near future

In this department the opportunities for clinical research are without limit Unfortunately, by reason of lack of staff, no more is possible than to attempt surveys of a small fraction of the clinical field which is available Tuberculosis has been studied (Kirkaldy-Willis 1946) and there have been reports on certain orthopaedic problems (Kirkaldy-Willis 1947 1948) but much remains to be done In writing these observations the kind permission of the Honorary Director of Medical Services Kenya is acknowledged

Mr Osmond-Clarke (London) has returned recently from Nairobi and he writes with enthusiasm of the Orthopaedic Centre of the Nairobi Hospital Kenya He visited not only the wards but the workshops and rehabilitation unit and says "Mr Kirkaldy-Willis has done well His ward orderlies theatre orderlies rehabilitation orderlies plaster room boys and one African surgeon are all fired with tremendous enthusiasm The nursing service is deficient because there is only a handful of white nurses but when someone becomes aware of the enormous pool of African males and females and has educated them things will improve in the nursing world Meanwhile it is quite amazing to see the most excellent artificial limbs which are made on the spot and fitted carefully The patient is trained thoroughly in walking before he leaves hospital—all in the best Roehampton style"

FIG 2

Carpets woven by convalescent patients in the orthopaedic centre Nairobi

FIG 3

Patient with double amputations fitted in Kenya with artificial limbs "in the best Roehampton style"

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Igbobi Orthopaedic Hospital, Nigeria

Mr T L Lawson Orthopaedic Surgeon at Igbobi Orthopaedic Hospital, writes from Lagos—This hospital was designed and erected by the Nigerian Government to meet military requirements for reconstructive surgery and rehabilitation with the ultimate aim that it should become a civilian orthopaedic hospital for Nigeria After the war, conversion took place rapidly Early in 1946 it became an Orthopaedic Hospital with one surgeon one sister and little equipment—not even proper beds or sterilizers In two and a half years it has expanded to a unit with four sisters, sixty nurses, two physiotherapists a thriving training school for African physiotherapists an occupational therapy department a limb-fitter with a staff of skilled technicians for making fully articulated limbs and orthopaedic appliances and a radiographic staff The equipment is excellent and the few things lacking are being provided gradually The kitchens, laundry,

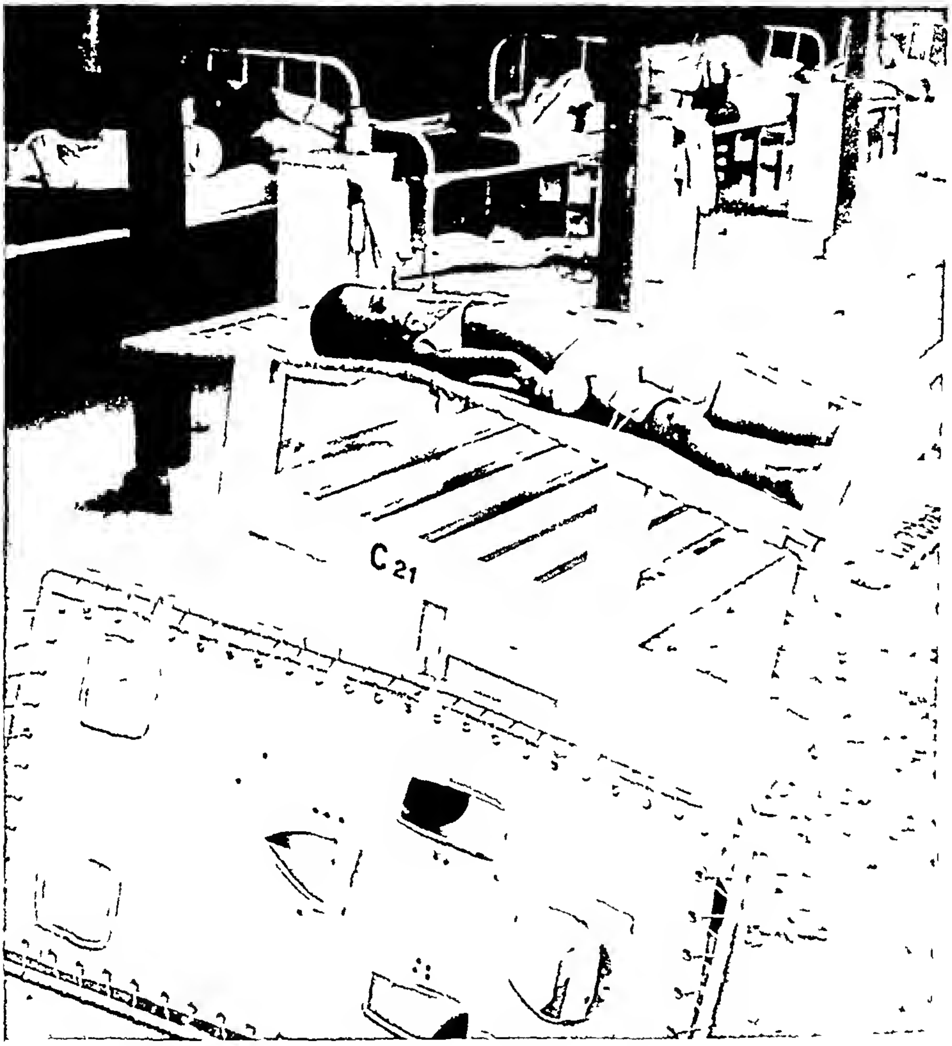


Fig 1

Cheap mobile frame with turning case constructed in our own workshops for tuberculosis of the spine

autoclaves and operating theatre are all served with electricity and steam-heat from a central source There is a swimming pool and gymnasium which would be the envy of many hospitals in the United Kingdom The present bed capacity is 180 in the near future it is hoped to build ward accommodation for 240 general orthopaedic cases (the present wards being rather unsuitable temporary expedients) and also a separate accident unit with a further sixty beds, an operating theatre radiographic and other equipment

Almost all the varieties of crippling complaint which are found in the United Kingdom are seen in Nigeria often in their more gross forms At the time of writing cases occupying the 180 beds include

tuberculosis of the spine—54 tuberculosis of other joints—21, simple fractures—15, compound fractures—9 poliomyelitis—9 fractured spines with paraplegia—5

Among other cases are examples of fragilitas ossium, Perthes' disease, osteomyelitis, ununited fractures malunited fractures Little's disease rickets, and a varied collection of bone tumours Over 60 per cent of our cases are children, of different tribes from all parts of Nigeria

Some of our problems are much the same as in England, particularly the size of the waiting list and the lack of trained staff From the purely clinical point of view, there are many minor differences Inability to elicit a case history of any degree of accuracy is disconcerting One is compelled to rely largely on physical signs and radiographic findings At the outset, in view of the huge number of cases we would be called upon to treat, it was decided to risk early operation for tuberculosis of the spine Many spinal fusions were performed, using iliac bone grafts in quite young children The early results were astonishingly good but we were not long in discovering that the results were just as good after conservative treatment The rate of healing seems to be more rapid than in England, especially when concomitant infections such as malaria and helminthiasis are treated The effect on these patients of good food and a well-ordered life has to be seen to be believed For climatic and economic reasons we have designed a cheap mobile frame for the treatment of tuberculosis of the spine, it is of simple construction, is made in our own workshops and is easy for nursing (Fig 1) Similarly we have had to make a well-ventilated modification of the doll s collar (Fig 2)

Fig 2

Climatic and economic reasons make it necessary for cervical collars to be well ventilated and simple in construction

About one thousand fractures a year are treated and so far the impression is that healing is very rapid indeed in spite of poor diet Fractures have to be immobilised very securely ambulatory plasters must be strong The patients desire to remove skin traction in the small hours of the night is very frequent so that one is more inclined to plate a fractured femur than would be the case in England For economic environmental and occupational reasons, treatment has often to be radical rather than conservative as for instance the performance of triple arthrodesis for a paralytic drop foot or osteotomy instead of altered shoes or splints for genu valgum There is an alarmingly high incidence of tetanus but on the other hand the resistance to traumatic shock is relatively high

The ultimate aim is to make this hospital the headquarters for the administration of a country-wide accident and orthopaedic service and for the training of staff Such a service is essential in a country where physical incapacity is much more serious in its economic effects than in a more highly developed society and since the population of Nigeria is over twenty millions it will have to be extensive Unfortunately expansion is bound to be slow because even apart from staff shortages financial considerations loom large The building of a hospital service from four bare walls has been stimulating, but even this could not have been achieved if it had not been for the tremendous enthusiasm which has been shown by all the members of all the departments

Orthopaedic Work in Mauritius

Mr J M Fitton, Surgeon in charge of the Orthopaedic Service in Mauritius writes The hospital service of Mauritius had no orthopaedic department until 1945 when a severe epidemic of poliomyelitis occurred It is true that a department had been planned, but at the time that we had to deal with 1 100 cases of poliomyelitis there was no department Accommodation was required urgently and it was decided to establish an emergency hospital in a disused naval camp on a racecourse at Floreal, on the plateau in the centre of the island Professor Seddon and others who came out from England to organise the medical care and study the epidemiology of the outbreak opened this hospital in April 1945 Members of the Mauritian branch of the British Red Cross formed the nursing staff The hospital is still in use but it is to be replaced by a new and more permanent building the construction of which will begin in the near future

In the first year the Floreal hospital consisted of nine wards with 225 beds all of which were occupied, and a physiotherapy department equipped with spring suspension apparatus an exercise pool and a walking ring Since 1946 the number of wards has been reduced to six, and about one hundred patients with poliomyelitis are still in hospital Four huts have been taken into use for other purposes One has been converted to a schoolroom equipped by the Department of Education with a hospital staff of three teachers A second hut has been made into an operating theatre it leaves much to be desired but it is at least possible to carry out such surgical treatment as may be required In a third hut a carpentry and cobbling shop has been established serving as a handicraft room for older boys and as a place for

FIG 1

FIG 2

FIG 3

Types of deformity seen in the Floreal Hospital Mauritius—tuberculous kypho scoliosis (Fig 1) untreated congenital club foot (Fig 2) severe deformities after poliomyelitis (Fig 3)

minor repairs The fourth hut has been divided to form an out-patient department a records office and an occupational therapy department All orthopaedic appliances are made in the workshops of H M Prisons under the supervision of an officer who spent a year in England on a special training course the labour is supplied by prisoners and a few outside technicians Despite almost complete lack of machinery appliances for over five hundred patients have been made and kept in repair

Towards the end of 1946 an orthopaedic service was started in the two most important general hospitals, and recently it has been extended to a third Weekly out-patient clinics are held at each hospital and beds are set aside for in-patients with orthopaedic conditions, though eventually these will be treated at the orthopaedic centre Treatment is given three days a week by physiotherapists and a remedial gymnast from Floreal Hospital

Difficulties have been encountered in treatment Most of the inhabitants of the island belong to the labouring class they are uneducated and many of them live in squalid conditions Persuasion and constant persuasion has been necessary to overcome parental prejudice against the admission of children to hospital and even at times to the fitting of appliances It has often been impossible to maintain the use of appliances by reason of severe scabetic lesions of the affected limb which tend to persist owing to the bad home conditions That these difficulties have been largely overcome has been due to the enthusiastic work of hospital nurses who have acted as home visitors since 1945 and to the happy atmosphere which exists in the Floreal Hospital Follow-up clinics have been held weekly at the hospital and at intervals of three to six months in each district of the island The progress of treated cases has been observed and many patients with previously unrecognised poliomyelitis and other orthopaed

conditions have been examined Since 1946 about two hundred and fifty old cases of poliomyelitis have been recorded More than half of them date from before 1945, and analysis shows that the disease existed in Mauritius as far back as the last two decades of the nineteenth century There must have been several small outbreaks of the disease, although previously there was no epidemic Poliomyelitis is also endemic in the neighbouring French islands of Reunion and Madagascar In Madagascar the first epidemic occurred between December 1946 and March 1947 when nearly three hundred people were affected The possible occurrence of a further epidemic of poliomyelitis has been constantly in mind but since 1945 there have been only sporadic cases In 1946 twenty-seven new cases were recorded in 1947 there were nine, and in 1948 up to the end of October, only eight

Orthopaedic surgery in Mauritius differs in many respects from that with which one is familiar with in England In general lesions when first seen are more advanced (Figs 1–3) There is a high incidence of acute and chronic, tuberculous and pyogenic infections of bones and joints, which though striking is not surprising in view of the poor general health of the population One gains the impression, which is difficult to confirm that diseases of the nervous system are unusually common, especially in the poorer classes Congenital deformities are frequent The commonest deformity is congenital club foot (135 cases so far) having been neglected, it is usually difficult to treat (Fig 2) By contrast congenital dislocation of the hip joint is rare only three cases having been seen in the same period

UNION OF SOUTH AFRICA

Pretoria—At Pretoria University Medical School (Afrikaans medium) an orthopaedic department was established about four years ago under the control of the Department of General Surgery Dr Johan du Toit, with his staff of assistants controls a unit of 300 beds half of them European Much of the work is traumatic but for long-stay cases a modern after-care home was built and opened last year There are open-air terraces wide glass doors and beds which can be easily wheeled out of the spacious wards The buildings are adapted to Pretoria s subtropical climate The ceilings are high and there is ample ventilation The architectural design allows for expansion, and the essential services are so planned that there may be extension to 200 beds Wards are so arranged as to facilitate classroom teaching with blackboards covering the whole south side of each ward

Non-European facilities will soon be amplified at Atheridgeville by the construction of an orthopaedic unit in the residential area of the non-European section at a cost of £110,000 Large contributions have been received from the Nuffield Fund of Great Britain the Native Trust and the Voluntary Cripples' Care Organisations The Provincial Government has approved the scheme offered to make up all that is lacking and meet running expenses

Johannesburg—Here also there has been rapid expansion of orthopaedic services Mr J M Edelstein, Nuffield Lecturer in Orthopaedics, is chief of the Department of Orthopaedics at the Witwatersrand Medical School and senior surgeon to the Johannesburg group of hospitals controlling about 250 beds with a staff of ten registered orthopaedic specialists Many others are in training The 1 500 bed Baragwanath military hospital built by the Imperial Government during the war and then staffed largely by South Africans, has been taken over by the Provincial Hospitals Department for non-European work and 150 beds have been allocated to orthopaedics A large pavilion is being allocated for the treatment of tuberculous disease of bones and joints Negotiations are in progress for the establishment of a non-European nurses orthopaedic training centre

At the Witwatersrand Medical School a Nuffield Museum of Orthopaedic Pathology is growing rapidly under the direction of Mr Edelstein Post-graduate teaching has now been continued for five years The volume of clinical material is so great that post-graduates have practical apprenticeship on a scale almost unknown in any other overseas clinic

At the Hope Convalescent and Training Homes cripples in all stages of treatment are given routine school education as well as vocational training under the direction of the Transvaal Cripples' Care Association At the Hope Training Home the number of beds is being increased to two hundred

Cape Town—Mr Hamilton Bell, who is in charge of the orthopaedic section of the Cape Town group of hospitals has approximately 200 beds and controls the treatment of all fractures Orthopaedic work has been developing in Cape Town and Johannesburg for a quarter of a century Nevertheless progress was slow until Lord Nuffield made his donation of £100 000 and Professor Girdlestone of Oxford England, visited the centres and gave advice Since then the National Council for the Care of Cripples has flourished Four provincial Cripples Care Societies and other affiliated organisations have developed Under the guidance of Mr Justice Feetham and Mr Charles Te Water president and chairman of the Nuffield Fund, interest has been stimulated and the growth of many orthopaedic centres has been fostered The moving force in these projects has been Mr Charles Te Water now Ambassador Extraordinary to the Union Government

The Chamber of Mines Hospital, run by the Rand Mutual Assurance Company, is at present the only large-scale private organisation providing comprehensive traumatic services to an industry Employing 40,000 European miners and 250,000 Bantu workers this industry has for a quarter of a century organised an industrial medical service The Chamber of Mines Hospital which, ten years ago, cost approximately £270,000 is run by a full-time administrative staff, a highly specialised legal department, a group of part time specialists and a team of full-time industrial medical officers The radiological department under

FIG 1

The Hope Convalescent Home Johannesburg Part of the open terrace on Parktown Ridge where crippled children have their schooling in the sun

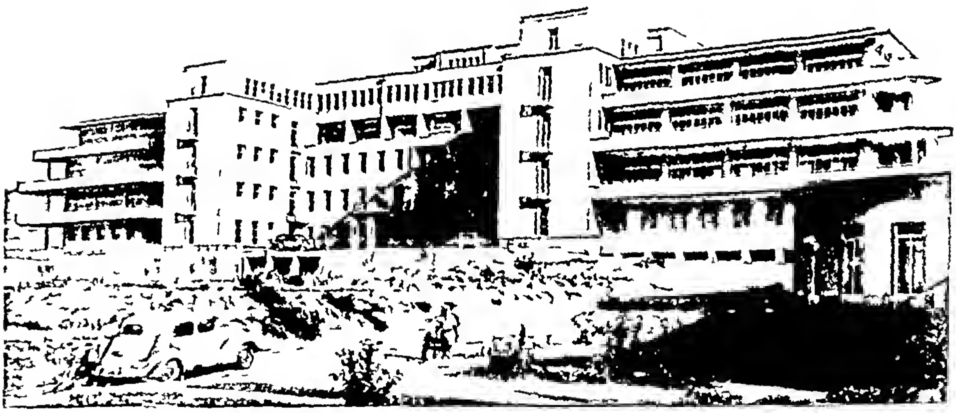


FIG 2

The orthopaedic and general surgical wards of the private Industrial Hospital for European employees of the Gold Mines Cottesloe Johannesburg

Dr M Weinbren is an example of supreme efficiency This hospital stands as a model for the country i proving that efficiency pays in the treatment of injured workmen

The South African Railways, controlled by the Government decided three years ago to institute an orthopaedic service for its injured employees The experiment is still in progress and we await with interest the results of actuarial analysis in a specialist service developed by one of the largest employers of labour in the country

Mr G T du Toit of Johannesburg, member of the British Editorial Board of the Journal who sent this report of the development of orthopaedic surgery in South Africa, reminds us that in his country much resistance and some ignorance has had to be overcome He is nevertheless proud to believe that after years of antagonism and inertia, orthopaedics is gaining recognition in the Union He recalls that there is still a vast reservoir of untouched orthopaedic work But he is convinced that progress will continue and that very great strides have already been made

FRANCE

French Society of Orthopaedic Surgery and Traumatology—The twenty-third meeting of the French Society of Orthopaedic Surgery and Traumatology was held in Paris on October 2 1948, under the presidency of *M Marcel Boppe* (Paris) There were visitors from other countries including President Meyerding President Valls, President Frejka, President Lorenz and Messieurs Scholder Van Nes Delchef, Soeur Ortolani Yotchich, and others

Treatment of Inequality of Leg Length—This was discussed by *M Pierre Berhand* (Paris) and *M Albert Trillat* (Lyons) Increasing the rate of growth of the shorter limb by venous stasis physical therapy and sympathectomy was rejected as unreliable Delaying the growth of the longer limb was believed to be more satisfactory Epiphysiodesis was the procedure of choice Operative leg lengthening was frought with many dangers whereas operative shortening of a limb was almost free from risk Fixation of the fragments had been facilitated by intramedullary nailing

Treatment of Fractures of Both Bones of the Forearm in the Adult—This was discussed by *M Robert Soeur* (Brussels) Manipulative reduction should be attempted when it was judged that a stable position might be achieved Open reduction, when necessary should usually be followed by a simple well-moulded plaster When internal fixation was deemed necessary intramedullary nailing seemed to be the method of choice The nail should be large enough to fit tightly in the medullary cavity in order to avoid the possibility of rotation *M Marcel Fevre* (Paris) described his management of these fractures in children In most cases manipulative reduction was satisfactory with plaster immobilisation for six or eight weeks Only irreducible fractures needed open reduction Plaster fixation was sometimes supplemented by intramedullary Kirschner wires

Appointment of Merle d'Aubigne to the Chair of Orthopaedic Surgery, Paris—It is with great pleasure that we congratulate Robert Merle d Aubigne who is well known in Great Britain and the United States, on his appointment as Professor of Orthopaedic Surgery in Paris in succession to Paul Mathieu Professor d Aubigne has many friends in the English-speaking nations He is determined that the bonds of friendship between British and French orthopaedic surgeons should be sustained We can say no more than that we support him in his endeavours Long may we remain friends and colleagues and long may we co operate To our friend Robert we offer good wishes and to our colleague Professor Merle d Aubigne, we offer congratulation

CZECHOSLOVAKIA

Czechoslovak Society of Orthopaedic Surgery—A meeting of the Czechoslovak Society of Orthopaedic Surgery and Traumatology was held in Prague from September 23 to 26, 1948 Many papers were presented to an audience which included visitors from Poland Bulgaria and America

Congenital Dislocation of the Hip—*Professor Jan Zahradníček* (Prague) said that in correcting disordered mechanics of the hip joint it was necessary to consider the altered neck-shaft angle of the femur If anteversion persisted the final result would be imperfect even although the short-term result might appear promising With these factors in mind he had devised an operation Through a lateral approach the greater trochanter was divided and retracted upwards with attached muscles The dislocation was reduced and an osteotomy of the upper end of the femur performed with removal of a wedge of bone to correct deformity of the neck-shaft angle Internal fixation of the fragments was combined with plaster immobilisation for three weeks followed by active exercises in traction *Dr Miroslav Jaros* discussed the etiology of congenital dislocation of the hip and the possibilities of a mechanical origin as opposed to that of inherent developmental anomaly Overwhelming evidence pointed to a developmental cause this was indicated by the hereditary tendency frequent association with other developmental defects and occurrence of the anomaly in certain definite localities The most probable explanation was spontaneous mutation of genes from interbreeding *Professor J Hanausek* (Prague) described a retentive apparatus which in his practice had displaced plaster immobilisation Replacement must be gentle and not violent Abduction of the thighs should not be greater than 60 degrees To-day there was no indication whatever for the Lorenz frog-plaster in 90 degrees of abduction His biomechanical apparatus was more successful *Professor B Frejka* made a plea for conservative treatment in patients under three years of age Reduction

was accomplished by gradual and gentle pressure rather than by manipulation under anaesthesia. Abduction was maintained for at least one to two years. If the roof of the acetabulum was not then developed satisfactorily, a shelf operation was performed.

Pulled Elbow.—*Dr V. Tosovsky* (Prague) described experiences of fifty cases of "painful supination" or "pulled elbow," the pathology of which was a perannular subluxation of the head of the radius.

Secondary Sexual Character at Puberty.—*Dr Eduard Bena* (Prague) reported studies of 1,700 boys with relation to the development of sexual characteristics. He related his work on physical and intellectual development to that of Verhulst, Robertson, and Brody.

Tissue Transplantation for Many Disorders.—*Professor Jan Zahradníček* (Charles University, Prague) gave an account of one thousand tissue homotransplants, autotransplants and animal transplants. A fragment of placenta, amnion, chorion, or skin, was cut from a living or dead body, refrigerated and inserted under local anaesthesia into a pocket of the abdominal skin of patients suffering from Dupuytren's contracture, keloid scar, rheumatic arthritis, osteoarthritis, ununited fracture, painful callus, ulcer, neuritis, neuralgia, essential hypertension, gastric ulcer, asthma, eczema, tuberculosis, scleroderma, Buerger's disease, and psoriasis. Nearly all these patients were relieved; there were failures in only 20 per cent! Every patient became more vigorous and more florid! Old patients became young!

As an editorial comment we must say that we find it difficult to accept these amazing results. Can we have an assurance from Professor Zahradníček that the merit of the procedure has been checked scientifically by controlled series? During the recent war a Mission to the Soviet Union of British, American and Canadian surgeons learned of similar claims for similar procedures, but on returning home and testing the preparations in a series of controlled cases found it impossible to substantiate the claims.

SCANDINAVIA

The Scandinavian Orthopaedic Association met in Aarhus and Copenhagen on September 23 and 24, 1948, under the presidency of *Dr P. Bentzon*. More than twenty short papers were read and discussed. Over fifty members and guests attended, including visitors from the United States and Great Britain. *Professor Einharson* read a paper on the neuropathology of poliomyelitis. *Dr Momberg* showed excellent coloured illustrations of the surgery of the hand.

Danish Orthopaedic Society.—The 1948 annual meeting of the Danish Orthopaedic Society was held in Copenhagen under the presidency of *Dr A. Momberg*. Eleven papers were on the programme. The British Orthopaedic Association was represented by *Mr St J. D. Buxton* (London).

PORTUGAL

A Portuguese Orthopaedic Society has been established under the leadership of Dr Arnaldo Rodo, Dr Azevedo Rua, Dr Antonio Menezes, Dr Carlos Ramos, Dr Abel da Cunha, Dr Azevedo Gomes. The Society is now awaiting recognition by the Ordem dos Medicos of Lisbon. We extend to our friends, the orthopaedic surgeons of Portugal, our best wishes for the success of their new venture.

CORRESPONDENCE

International Society of Orthopaedic Surgery and Traumatology.—*Dr Delchef* (Brussels), Secretary-General, writes on the subject of the Editorial comment on the International Society published in the British issue of the Journal of Bone and Joint Surgery (Vol. 30-B, November 1948, page 480):

"I share completely your point of view as to the obligations of an editor, and I much prefer stimulating and constructive criticism to praise which only renders sterile those who are feeble enough to listen. But criticism must be well-founded, and as Secretary-General of the Society I have been a little worried by the comments of which you have been the echo.

"The Statutes of the Society have been published regularly in the 'Comptes Rendus des Congrès,' first in Paris in 1930, then in London in 1933, and also in Bologna and Rome in 1936. These statutes decide the method of election of members and delegates under a general presidential directive which is responsible for every final decision. They regulate also the question of language and the time allowed for the delivery of contributions.

It may be that reproaches have been made in consequence of accidental and independent circumstances. Before the Rome Congress there were 256 members who had the right to receive the Report of Congress. To day the number is more than doubled—there are 552 members, 74 elected in Rome, 112 in Brussels and 120 in Amsterdam. The report of the Brussels Congress did not publish the Statutes because the International Committee wanted to introduce certain amendments, without however altering the spirit of them. Thus 296 of our members do not yet possess a copy of the Constitution and Statutes. I indicated this anomaly to the General Assembly at the last Congress and no doubt it explains the criticism which has been submitted to you. But it has been my agreeable duty to send to you all the regulations of the Society as they exist to day. Article 6 of the Statutes makes it possible for modifications and amendments to be made.

As to the time allowed for delivery of a contribution I believe that a speaker should be able to make his point in ten minutes. Communications which are most worth listening to are usually the shortest.'

Treatment of Fractures of the Shaft of the Femur—*Dr Edward Harlan Wilson* (Columbus Ohio) writes to say that the British Journal of Bone and Joint Surgery did not report accurately his observations on the treatment of fracture of the shaft of the femur at the joint meeting of the British, American, and Canadian Orthopaedic Associations in Quebec June 1948. We recorded in Volume 30-B, page 572, that in the treatment of fractures of the femoral shaft 'Dr Harlan Wilson believed that internal fixation with screws and vitallium plates was the treatment of choice.' Dr Harlan Wilson regrets that 'poor choice of language and expression has given rise to this conclusion' because he had no intent of making such a statement. He writes: 'The paper reviewed the reasons why open reduction of fractures of the femur had become more prevalent in the United States than in earlier years. It did point out certain advantages. It also mentioned that infection was one element of danger. A small series of cases was then presented in which open reduction had been used not to justify it as a method of treatment but as an experiment in early and quick rehabilitation. One disastrous case was included. No conclusion was drawn because of the relatively few patients in the series. My own feeling was that while open reduction had resulted in early and excellent function, yet the one infectious disaster perhaps nullified all advantages which had occurred in the other cases.'

A Doctor's Personal Experience of Poliomyelitis—An article published in the Lancet (October 9 1948) by a doctor records his own experience as a victim of poliomyelitis. The contribution is of interest because it illustrates the point of view of the patient. The attack was severe. Breathing was at first difficult and it demanded concentration. In the early stages 'lumbar puncture was a great comfort.' Recovery began after the third day and continued steadily, although muscle tenderness persisted for six months. The muscles were exercised from the start. At the sixth week it took forty-five minutes to turn over in bed, but this could be accomplished in five minutes at the twelfth week. Walking, even with assistance, was not possible until after eighteen months. Nevertheless, in the third year walks of two miles were accomplished with the aid of one stick, and in the fourth year it was possible to walk ten miles in five hours without a stick.

The experiences of this observer support the general view that early return of voluntary muscle power is a good sign because muscles which regain power quickly maintain their lead and can be expected to become powerful; on the other hand the belief that muscles will not recover useful power unless they show recovery by the third month is refuted. All affected muscles gained more strength in the second three months than in the first three, and much more in the second six months than in the first six. Improvement in muscle power is still being made even after six years. The ill-effects of stagnation and the immense value of physical and mental stimulation are emphasized. Frequent passive movements were a great delight; massage and warmth were comforting and they eased the muscle tenderness.

Fatigue is regarded by this doctor-patient as an essential part of muscle development. Nature seems to provide reserves beyond ordinary demands and if this reserve is steadily encroached upon she builds a larger one. It is the activity that the patient can only just perform or cannot quite perform that brings back strength. If increasing demands are not made no improvement can be expected. At the end of a session of effort the muscles should be appreciably weaker. Though fatigue is essential in developing increase of power it may nevertheless be dangerous if it is cumulative. There must always be a period of rest corresponding to the degree of exercise. If routine is so planned that muscles recover their greatest strength at some time every day, there is nothing to fear.

In summary it is said that there appears to be no limit to progress, that the beginning is the slowest, that fatigue is essential for muscle development, that rest and proper diet are also essential, and that the greatest problems are stagnation and loss of morale.

Rowley Bristow Memorial Fund—*Professor George Perkins* writes: 'The Rowley Bristow Fund now amounts to £500. It is proposed to close the fund very shortly. Would those who wish to contribute kindly send their subscriptions to me at 149 Harley Street, London.'

Book Reviews

DUPUYTREN'S CONTRACTION WITH SPECIAL REFERENCE TO AETIOLOGY AND IMPROVED SURGICAL TREATMENT ITS OCCURRENCE IN EPILEPTICS NOTE ON KNUCKLE PADS By Tord Skoog 9¾ × 6 in Pp 190, with 50 figures, including 4 colour plates (Supplement 139 Acta Chirurgica Scandinavica 96) 1948 Uppsala Almquist & Wiksells, Boktryckeri AB Paper cover

Ever since 1832, when Dupuytren correctly attributed the finger contraction which bears his name to changes in the palmar aponeurosis surgeons and pathologists have sought unsuccessfully an adequate explanation of the condition It has been attributed to such widely varying pathological processes as syringomyelia gout, pituitary deficiency and local neoplasm Nevertheless very few of the theories advanced withstand close analysis Many are clearly based on isolated clinical coincidences Indeed a review of the literature gives cause only to deplore the lack of scientific reasoning of many of the authors In the circumstances of this widespread confusion it is refreshing to read a well documented and reasoned review of the whole problem such as is contained in Dr Tord Skoog's paper Moreover this work will be of special interest to British surgeons because it is based on material largely accumulated at the Plastic Surgery unit of the Queen Victoria Hospital at East Grinstead directed by Sir Archibald McIndoe

The greater part of the monograph is devoted to a consideration of the clinical and pathological features of the contraction with a full review of the literature This leads up to an exposition of the author's own conception of the cause Dr Skoog is convinced that the primary pathological lesion occurring usually in patients with an hereditary predisposition is a rupture of aponeurotic fibres of the palmar fascia Small haemorrhages follow with the subsequent formation of fibrous tissue which contracts like any other scar This process oft repeated leads ultimately to the formation of the typical dense contracted bands of fibrous tissues which characterise the disease This conception is based mainly on histological and experimental evidence Whether or not the conclusions are fully acceptable it must be admitted that the arguments are based on sound reasoning and that much of the accumulated evidence lends support to the possibility that trauma does at least play a part in causation

The paper concludes with a detailed and well illustrated account of the operative technique developed by McIndoe for excision of the palmar aponeurosis inelegantly called aponeurosectomy The results reported from a series of fifty such operations are impressive It is not stated however whether the operation is used exclusively for all cases of Dupuytren's contracture irrespective of severity or whether the alternative technique of amputation of the grossly contracted and stiff fifth finger has been employed for the worst cases to this extent the stated results must be regarded with reserve

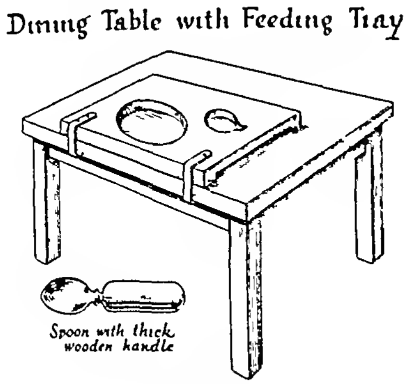
Dr Skoog's paper will be of interest both to orthopaedic surgeons and plastic surgeons as well as to many pathologists Like most exhaustive surveys it is somewhat heavy reading but this is mitigated by the excellence of the English translation —H Osmond-Clarke and J Crawford Adams

A WAY OF LIFE FOR THE HANDICAPPED CHILD By Eirene Collis M C S P M A O T (with a Foreword by Somerville Hastings M B M S (Lond) F R C S (Eng) M P and an introduction by Winthrop M Phelps M D F A C S 8½ × 5½ in Pp 168 with 12 figures Glossary Index 1947 London Faber and Faber Ltd Price 10/6

In the United States, certain workers, notably Dr Winthrop Phelps of Baltimore have approached the problem of cerebral palsy more intensively and comprehensively than has been usual in this country Phelps has stressed particularly the need for accurate diagnosis and careful mental assessment Manifestations of cerebral palsy may be spasticity athetosis ataxia rigidity or tremor In congenital spastic diplegia mental defect is frequent because the lesion is in the cerebral cortex whereas, in athetosis the lesion is in the basal ganglia and most patients have a normal intelligence although this is often masked by difficulties of speech swallowing and hearing Such athetotic patients often exhibit superimposed muscular tension which is mistaken for spasticity and in consequence they are sometimes subjected to operations which are unsuitable and indeed harmful It is to these patients almost as numerous as the true spastic diplegics that Phelps has given special attention

Mrs Eirene Collis is a physiotherapist and occupational therapist who has had the advantage of working under Dr Phelps to whose inspiration and encouragement she pays tribute In 1943 she opened a treatment centre at Queen Mary's Hospital for Children Carshalton and her valuable monograph is based largely on experience gained there After a general description of the types of cerebral palsy and of the psychological problems in children suffering from them Mrs Collis describes at length the principles of treatment and the details of re-education relaxation and specific muscle training some of the ingenious mechanical aids are clearly illustrated These sections are excellent Future editions might usefully

include detailed descriptions of the methods of occupational therapy, speech training and school work The need for accurate and standard records is wisely stressed, and the graphic methods which have been found most valuable are illustrated Throughout, insistence is placed on team work among children, parents and therapists



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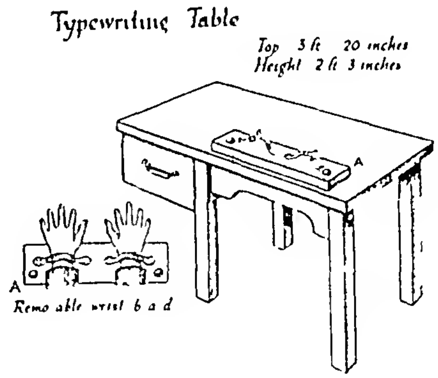

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Simple apparatus used in the training of children with cerebral palsy

In general, the approach is well balanced and comprehensive the principles enunciated by Dr Phelps are presented clearly, and the details of specific treatment are supplemented by the author's own wide experience in this difficult field This monograph should be read carefully by both medical and lay members of any cerebral palsy team —E S EVANS

PROGRESS IN ORTHOPEDIC SURGERY FOR 1945 *A Review prepared by an Editorial Board of the American Academy of Orthopaedic Surgeons* Reprinted from Archives of Surgery 1947, 54 and 55 10¼×6¾ in Pp 327 Index Chicago American Medical Association Paper cover

The American Academy of Orthopaedic Surgeons renders a great service to orthopaedics in issuing the annual "Progress in Orthopedic Surgery" the indexed reprint from *Archives of Surgery* is an indispensable volume Selection and abstracting are expertly done and the members of the Editorial Board, with their associates, deserve, not only grateful thanks for their great labours, but also congratulations upon the outcome The volume fully maintains the usual high standard Its lateness depends on the delay in publication of the relevant *Cumulative Index Medicus* —H Jackson BURROWS

THE RADIOLOGY OF BONES AND JOINTS By James F BRAILSFORD, M D Ph D, F R C P F I C S Fourth edition 10×8 in Pp xiv+760 with 615 figures Index 1948 London J & A Churchill, Ltd Price 63/-

The writing of a radiological text-book demands not only a wide knowledge of the subject but also facility in description especially of those fine changes which distinguish the pathological from the normal and may precede evident clinical disturbance hence the dearth of radiological text-books in English Such should be not only a guide to the student but also a reference book for the practitioner it should be comprehensive, well and simply written well illustrated and comprise a review of the world literature—a tremendous task Brailsford s first edition was mainly a work of reference but he has now made it also a guide for the student having added enormously to its value by recording his personal experiences and observations of cases carefully followed up He has stressed particularly the recognition of early changes and has related them to their clinical manifestations Without such a demonstration of living pathology radiology is a dead subject The first of the two parts into which the book is divided is concerned with normal and abnormal development of the bones and a topographical description of the whole skeleton, beginning with the hands and recording the pathology of each member The second part deals with general pathological changes in the bones and the radiological manifestations of general diseases which cause secondary changes in bone Acute and chronic joint conditions are fully described and are classified radiologically Tumours of bone are described in detail and their radiological and pathological appearances are correlated A full bibliography completes the text The illustrations are very good and their usefulness is enhanced by line-drawings which emphasize their important points Even more of these would help the student especially as the illustrations are perhaps rather small Otherwise there is little to criticise in the book except that it is a little irritating at times to have to look up so many pages to find

the complete radiological picture of a disease, so that continuity of reading is difficult This must be expected however in a reference book, and it is as such that this book should be a best seller The author is to be congratulated on a monumental work likely to become a universal classic, and the publishers are to be congratulated on the manner of its production The first edition showed signs of teething troubles the present shows maturity —P H WHITAKER

A ESCAPULECTOMIA TOTAL PAROSTAL NOS NEOPLASMAS PRIMITIVOS DA OMOPLATA By Fernando Ellis RIBEIRO 10 × 7 in Pp 216, with 85 figures Index 1947 Rio de Janeiro, Paper cover

This monograph on scapulectomy for the treatment of primary neoplasms of the shoulder blade provides information previously distributed in many volumes Every aspect of the scapula, normal and pathological is considered, and constant reference is made to work of numerous investigators There are sections on embryological development illustrated with original microphotographs on histology and centres of ossification Pages 31 to 110 describe the scapula and its articular connections muscles, blood vessels and lymphatics on the familiar lines of any anatomical text-book but also include fine points of difference found by anatomists and anthropologists These sections which contain no new observations are illustrated with photographs of finely executed original dissections and with line-drawings and diagrams from German works illustrating muscular action They are followed by a brief historical section in which there is an excellent review of early cases and more recent experience It is however, incorrect to state that Ralph Cuming (not Cumming) excised part of the scapula in 1808 This remarkable young surgeon performed in that year the first forequarter amputation Dr Ribeiro should give the priority for subtotal excision of the scapula to James Luke of the London Hospital and the date as October 1828 (LUKE, J 1829 London Medical Gazette, 5, 235)

Pages 117 to 131 are concerned with the technique of excision of the scapula, based on actual cases dissections and an animal experiment, and illustrated with eleven beautiful drawings of each stage This is the best section of the work The stages themselves from boomerang incision to final drainage are clearly described in fifteen numbered paragraphs Then is included a section on variations in the standard technique as used by leading exponents and including some in which portions of the clavicle or humerus are removed The author here describes his own successful experiment with one of these techniques, using *Cebus Apella* as a subject this he illustrates with twenty-eight photographs Mortality statistics from many authorities are quoted but without reference to the author s own experience He does however state that in his cases there has been little shock and that functional results except for writing have been excellent The closing sections deal with indications for using this conservative operation as opposed to the mutilating operation of Paul Berger a classification of tumours affecting the scapula, and a brief statistical analysis of their incidence there is a concluding section on diagnosis The book is the fruit of immense industry and may fulfil the author s aim if this was to provide an abstract of all the relevant literature that was available to him It is not, however possible to come to any conclusion at the end of it and the absence of criticism or comment, together with the difficulty of deciding when the author is referring to his own work and when to that of others increases the problem of deciding what his own views on any point may be His bibliography is curiously incomplete thus Berger s classic work is omitted Dr Ribeiro has been ill-served by his anonymous publisher and has himself drawn attention to some 120 errata Not even this list is complete —J J KEEVIL

THE BRITISH ENCYCLOPAEDIA OF MEDICAL PRACTICE *including Medicine, Surgery, Obstetric Gynaecology, and other special subjects* MEDICAL PROGRESS 1948 Editor in Chief Rt Hon Lord HORDER, G C V O, M D, F R C P 9¾×6¾ in Pp x+511+(28), with 5 figures Index 1948 London Butterworth & Co, Ltd

"Medical Progress 1948" is a rather misleading title The work is a supplement to the British Encyclopaedia of Medical Practice, bringing this up to the beginning of 1948, and is composed of critical surveys (which do not include orthopaedics) recent pharmacological and therapeutic developments and abstracts These comprise the greater part of the book and are arranged alphabetically That on bone diseases is particularly good Other subjects of orthopaedic interest include joint diseases poliomyelitis various endocrine, nutritional and vascular disorders and so on The wide scope of the volume implies rather sketchy treatment of individual subjects and a limited value for specialists —H Jackson BURROWS

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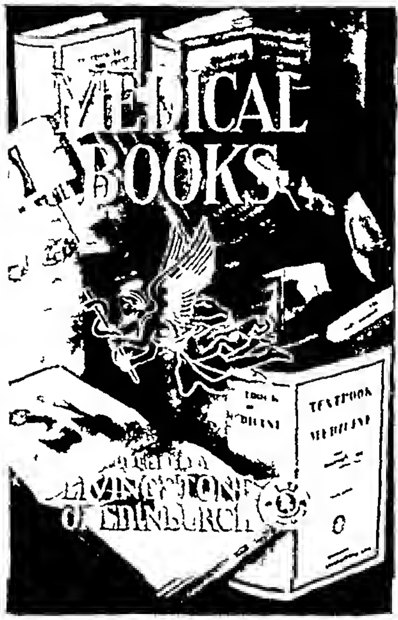

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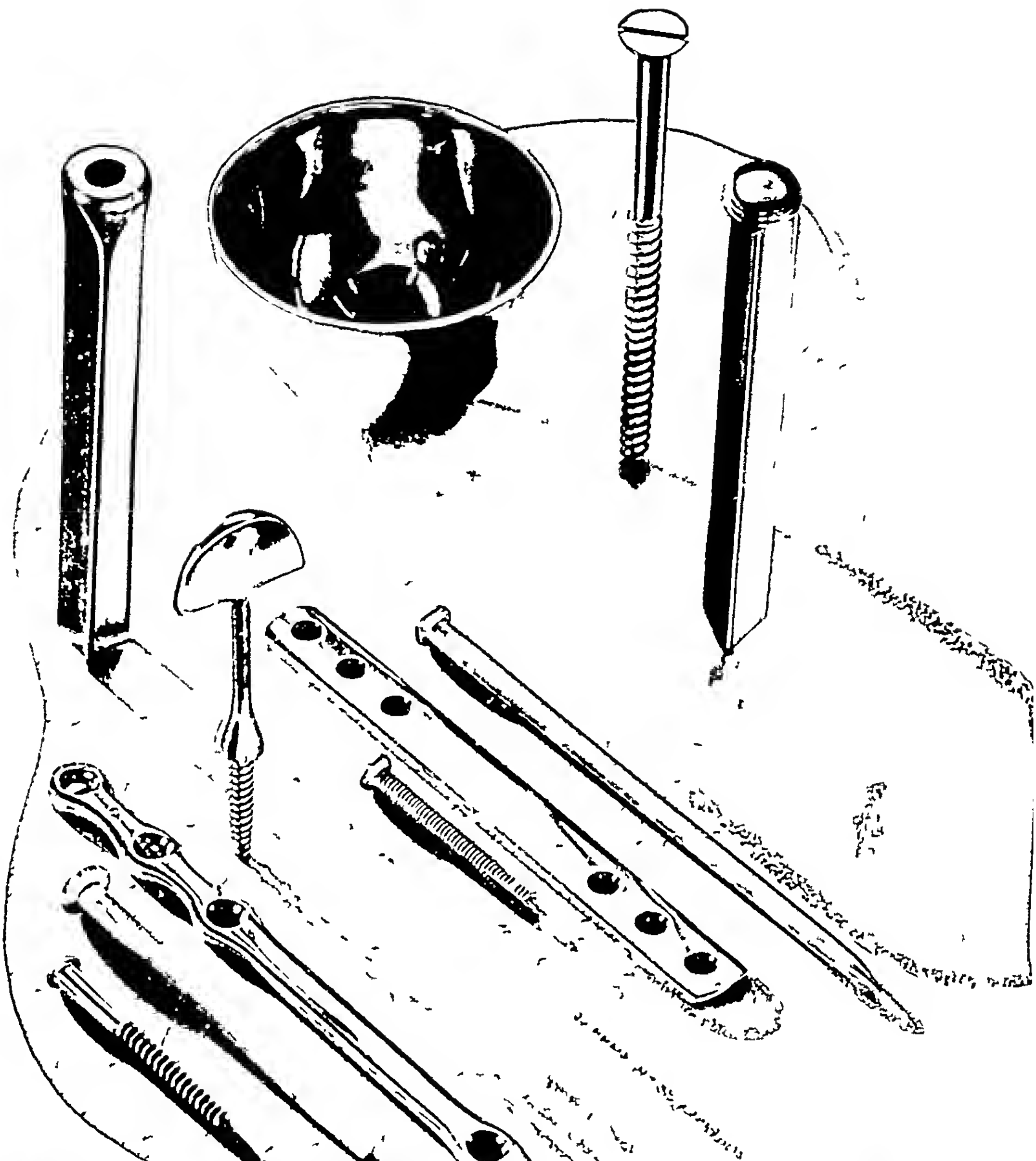


VOL 31-B, No 2

MAY 1949

The Journal of Bone and Joint Surgery

BRITISH VOLUME

OSTEOCLASTOMA OR GIANT-CELL TUMOUR OF BONE

To pathologists and surgeons of the nineteenth century the behaviour of the tumour which to-day goes by the name of osteoclastoma, or giant-cell tumour, seemed to establish it as a member of the bone sarcoma family Until radiographic aids to early diagnosis were available, many of these tumours were encountered only after they had attained considerable size and presented to the clinician's trained sense of touch the now almost forgotten sign of egg-shell crackling In spite of these destructive attributes the " myeloid sarcoma " behaved as a non-lethal lesion and was regarded by such masters as Virchow, Paget and Nelaton, as essentially benign

In our approach to the problem of the giant-cell tumour we no longer look to sarcomas of bone for analogies or contrasts in behaviour, although the rare malignant type of osteoclastoma is now a proven entity It is the relationship of giant-cell tumour to dystrophic lesions of bone that holds our interest We are familiar with the fact that osteoclastoma areas may be discovered in the mosaic histological pattern that is characteristic of the several anatomical types of fibrocystic disease of bone—a skeletal affection which on every account is a non-tumour lesion—and we have clinical evidence that after removal of a parathyroid tumour in the generalised form of osteodystrophia fibrosa, large cystic lesions, predominantly giant-cell tumour in structure and behaving for a time in tumour fashion, may regress without the need for local surgical attack Thus to-day we speak of the " giant-cell tumour process " in which at one end of the scale we see dystrophic lesions that may signify little more than abnormal manifestations of the process of repair in bone and, at the other end, the osteoclastoma as a tumour lesion, aggressive, malicious and on occasion endowed with malignant potentialities

In the past, histological kinship between the cyst and the giant-cell tumour has led to confusion in diagnosis Many giant-cell tumours recorded in the literature were in fact dystrophic cysts Geschickter and Copeland first made clear the distinction between dystrophic cysts and giant-cell tumours, the outstanding fact being that a solitary cyst of long bones is always a lesion of the *metaphysis* originating in childhood or adolescence, whereas the giant-cell tumour is a lesion of the *epiphysis* and is seldom if ever seen under the age of twenty years Most cysts run true to type but even atypical cysts, which have a special interest of their own, exhibit in some measure the tendency inherent in dystrophic lesions towards spontaneous repair The key-note in treatment of the cyst is stimulation of osteogenesis leading to obliteration of the cavity, which can be accomplished by the simple operation of packing with bone grafts or alternatively by controlled irradiation

The giant-cell tumour, on the other hand, in its true guise is always aggressive and destructive The key-note in treatment is prompt eradication or destruction of the tumour In early tumours of long bones the most desirable procedure is one in which the tumour tissue within the epiphysis can be eliminated with precision and without risk of damage to the articular cartilage Bloodgood showed long ago that this can be achieved by curettage and cauterisation To-day some surgeons prefer to collaborate with radiotherapists in the

treatment of early tumours and to confine surgical attack to more advanced tumours, particularly those where biopsy suggests impending or actual malignant change

In any attempt to evaluate what should not be regarded inevitably as conflicting forms of treatment, it is essential that our teaching should not be vitiated by failure to recognise the clear-cut distinction between giant-cell tumours and dystrophic cysts HARRY PLATT

GIANT-CELL TUMOUR OF BONE

In this number of the Journal the clinical details of eighty-four cases of giant-cell tumour of bone are recorded in five papers, and pathological features are reviewed by two recognised authorities whose opinions have earned the respect of the profession Until 1920, the nomenclature was confused and inaccurate Of the various names that have been applied the most reasonable is "giant-cell tumour"—a term preferred by most clinicians, though "osteoclastoma," which is preferred by pathologists, is acceptable Yet even Willis points out that the name osteoclastoma "does not necessarily imply specific derivation from differentiated osteoclasts" The virtue of a name is to convey a meaning and in the case of this lesion the meaning should be a tumour of bone which usually, but not always, pursues a benign course That it can behave like a malignant tumour has been known for nearly a century, and such behaviour was described by Sir James Paget in 1853

There are many problems and their solution has not been aided by the confusion that has arisen from the multiplicity of names, the publication of incomplete case histories, the inaccurate statements that have been copied from one author to another, and the undue emphasis that has often been placed on one or other method of treatment Certain features can now be clarified, but let us recognise that the mystery of this tumour, and the real nature of it, will be known only when the mystery of tumours in general is solved

There is now sufficient evidence to disprove the former belief that giant-cell tumour of bone is of epiphysial origin Before the epiphysis has fused with the diaphysis the tumour can be seen to arise independently and separately from it, in the metaphysial end of the diaphysis The tumour has such osteolytic properties, particularly in children and young adults, that the epiphysial cartilage offers no barrier and destruction may extend rapidly from the metaphysis to the epiphysis itself Moreover, in two-thirds of cases the lesion first develops after the epiphysis has completely fused It should no longer be thought that giant-cell tumour of bone is a disease of the epiphysis

In many respects the clinical and radiographic features are characteristic Nevertheless there is only one certain method of diagnosis—namely by histological examination Giant-cell tumour often mimics other lesions, particularly solitary cysts of bone Certain types of bone sarcoma may be clinically indistinguishable, especially the "medullary fibro-sarcoma" described by Scarff Plasmocytoma as a solitary lesion, and even metastasis from carcinoma or the more rare neuroblastoma, can at times show radiographic appearances that closely resemble those of osteoclastoma Without biopsy the diagnosis must always be speculative

With increasing appreciation of the life history of the giant-cell tumour, treatment has been simplified At one time limbs were amputated, then tumours were excised, later they were curetted, and now they are irradiated Irradiation is sometimes used only as a precautionary pre-operative or post-operative measure, but often it is used as the sole method of treatment One curious belief should be exposed, namely, that accessible tumours should be treated by surgery and inaccessible tumours by radiation If radiation is successful in inaccessible and deeply situated tumours why should it be denied to patients with accessible and superficial lesions? Naïvety must also be recognised in the proposal that curettage of the tumour, with or without implantation of bone chips, should be supplemented by radiation It must be asked, when this practice is pursued, what it is proposed to irradiate Is it necessary to radiate the bone chips? They surely do not need it Or is it proposed to radiate a cavity left after curettage? Many experienced radiotherapists have pointed out that treatment is more difficult and that failures, recurrences, complications and morbidity are

greater after such combination than after either therapeutic measure alone Like most compromises, this is no solution to the problem and it should be abandoned

In the search for truth certain fundamental principles become clear Tumours in the hands and feet should not be irradiated because there is too great a danger of injury from the radiation Tumours in children should seldom be irradiated because the treatment may cause epiphysial injury and deformity Case reports in the literature with a follow-up of not more than three to five years cannot be relied upon The long term effects of radiation in children, with irreversible damage that may be disastrous, cannot be judged in less than ten to fifteen years

In considering the response of giant-cell tumour to radiation two clinical types may be distinguished In the flat bones of the pelvis and shoulder girdle, and in the vertebrae, the gross characteristics of the tumour differ from those of tumours in classical sites around the knee joint Even in the femur and tibia, and sometimes in other long bones, these two types may be differentiated In one, the appearance is that of a cyst without trabeculation or bone expansion, the lesion is situated centrally, it is of small or moderate size, the rate of growth is slow, and there may be no external deformity In the other, there is expansion of bone and marked trabeculation, it occurs most commonly in the pelvis, and when it involves the long bones of the limbs it gives rise to deformity, obvious swelling and often spontaneous fracture In the experience of this writer, central non-trabeculated cystic tumours in the classical sites at the upper end of the tibia and lower end of the femur respond badly to radiation whereas trabeculated tumours with " soap bubble appearance " respond well, especially if they have not already been curetted There is nearly always arrest of growth of the tumour and complete re-ossification

Tissue doses should be small—seldom more than 2000 roentgens, the treatment being given in two, or even three, courses at intervals of six or more months The immediate reaction of increased decalcification that often precedes repair of the lesion is described in many cases reported in this number of the Journal

It is known that tumours that pursue a benign course may yet involve surrounding soft tissues and pass across joint cavities into neighbouring bones One example of such extension is recorded by Windeyer and Woodyatt, and Russell draws attention to the fact that soft tissue invasion is not necessarily sinister in its significance But it must be accepted that giant-cell tumour of bone does sometimes show evidence of malignancy It is easy to suggest that all tumours are potentially malignant and that giant-cell tumours are no exception in that they may lie within a varying range of malignancy, but this conception, though no doubt tidy from the pathological point of view, is of no help to the clinician Is it possible for a giant-cell tumour that appears histologically simple to metastasize? Does a benign tumour undergo malignant metaplasia? The contributions of Russell, Willis, Windeyer and Ellis make it clear that there is no certain distinction between benign giant-cell tumours and malignant giant-cell tumours that give rise to visceral and sometimes skeletal metastases even after ablation of the tumour and in the absence of local recurrence

That there are two forms of malignant giant-cell tumour is pointed out by Professor Russell In one, the lesion remains essentially a giant-cell tumour It was in this variety that Jaffe *et al* described morphological changes by which they believed that it was possible to distinguish the malignant from the benign form In the other variety, the stroma cells undergo metaplasia and the tumour is indistinguishable from an osteogenic sarcoma This type is of special interest in connection with treatment by radiation The series of cases reported in this issue of the Journal includes eight (excluding those in Paget's disease) in which a benign tumour, treated by radiation with or without surgical intervention, became a malignant tumour To this series can be added three from Westminster Hospital, not included in Prossor's report, where radiation was followed by malignant change It is well known, both from experimental and clinical evidence, that bone sarcoma can be induced by radiation Cahan, Woodward *et al* reported eleven such cases, osteogenic sarcoma developed

in irradiated bones six to twenty-two years after radiation Radiation is a form of injury and undoubtedly it may precipitate malignant change in a bone But it is only fair to point out that the dosage in experimental cases, and others in which malignant change occurred, was far in excess of the 2000 roentgen which is the dosage now used in treating giant-cell tumours Nevertheless the warning should be accepted The cure of giant-cell tumours by X-ray therapy should be achieved by moderate doses and the possibility that larger doses may give rise to sarcoma should always be in mind

The occurrence of giant-cell tumours in association with Paget's disease, as recorded by Professor Russell, is of great interest by reason of its rarity Has it ever been recorded before? It is also of interest because of the similarity between the bone changes of osteitis deformans and osteitis fibrosa, and the possible relationship between osteitis fibrosa and osteoclastoma

STANFORD CADE

TRAVELLING FELLOWS IN ORTHOPAEDIC SURGERY FROM THE AMERICAN CONTINENT—THE A B C CLUB

The first cycle of a new adventure has been completed Last year, thirteen young British orthopaedic surgeons were guests of American and Canadian hosts, they visited important orthopaedic centres in the North American continent and attended the historic combined meeting of the American, Canadian and British Orthopaedic Associations in Quebec This year, ten American and five Canadian orthopaedic surgeons were guests of British hosts, they visited orthopaedic centres in this country and made important contributions to the Spring meeting of the British Orthopaedic Association in Nottingham

The travellers were met on board the " Queen Mary " at Southampton by the President, ex-President, Treasurer and other Officers of the British Orthopaedic Association, and having made short shrift of Customs, and the problem of finding taxicabs at Waterloo, the memory that remains is that of the calm serenity of Big Ben and the Houses of Parliament, silhouetted in a moonlit sky The smooth-moving waters of the Thames, almost within reach of Pinafore Room of the Savoy Hotel where the official dinner of welcome was attended by nearly every London orthopaedic surgeon, promised the peace and calm which surely was to be needed in a hectic journey from London to Cambridge, Luton, Norwich and Newcastle, Edinburgh and Glasgow to Loch Lomond and the English Lakes, Liverpool, Manchester, Oswestry and Birmingham to Stratford-upon-Avon, Nottingham and the Sherwood Forest, Derby, Oxford, Bath, Bristol and Exeter to Stoke Poges, Windsor and the Golden Valley

The travellers were driven many hundreds of miles, at a very safe pace, by the reliable Irishman Pat, in the unheated omnibus which soon became known as the Deep Freeze It lacked in calories but not in confidence Still held in secret are the vivid and uninhibited impressions of American and Canadian members of the A B C club—the club of American, British and Canadian Travelling Fellows in Orthopaedic Surgery, established formally in Nottingham with only one rule—that every member would play his part in facilitating the visits of young orthopaedic surgeons from one country to the other A conception so warm in its ideals should not have been conceived in an environment so cold Our southern American visitors believe that bilateral cervical and lumbar sympathectomy is needed if Britain is to be appreciated Cambridge, the first halt on their journey, is still replenishing its stocks of full arm and leg length woollen underwear!

Ham Allan of Philadelphia fulfilled the rôle of leader with unfailing charm and competence and showed great skill in the delegation of responsibility Ted Dewar of Toronto was adjutant, and we are sorry that there was not time to learn more of his remarkable knowledge of scoliosis Don Blanche from Los Angeles thought much but spoke little—and always to the point Verne Inman of San Francisco won admiration for the fluency of his delivery at Nottingham when one photograph showed his own shoulder girdle bristling with fearsome

bone-transfixion pins John Fahey of Chicago heard everything, saw everything, and was ready to discuss everything, he received many cablegrams reporting yet further additions to his family and at one time it appeared that he might even be the parent of quintuplets, but with undisturbed equanimity he left, as he arrived, the proud parent of a single child that he has not yet seen Benny Obletz of New York did not, as we had been warned, " take or talk the nerves out of every hip joint ", he was objective and modest in his claims Carroll Larson of Boston distinguished himself not only by modesty but by making the best speech of all that were delivered at the Annual dinner of the Association and by arriving on board the last day, unshaven and unslept, happy in having advised on arthroplasty Bill Bickel of the Mayo Clinic shamed us by his knowledge of E, A, F, DCA and ACTH and by his ability as a woodsman, he can indeed handle an axe Leo Walker of Montreal sustained the Canadian reputation for skilful colour cinematography with Mickey Mouse interpolations Hugh Smith of Memphis played nearly every piano in Britain, with the cover of a keyboard he nearly amputated the fingers of the Editor of this Journal, and he was the first American to hold up a British express train Frank Paterson of Vancouver represented the Western Canadian seaboard and spoke well for his colleagues at the Robert Jones and Agnes Hunt Orthopaedic Hospital Bill McKinnon of Winnipeg, who knew us during the war, still speaks fluently in public while remaining modest and reserved in private conversation Ramsey Straub of New York will be remembered for his careful presentation of the problems of lumbo-sacral fusion, but we cannot forget the tug " Romsey " of immense girth and power that moved the " Queen Mary," and we will always think of him as " Friar Tuck of Sherwood Forest " Ben Fowler of Nashville was never lacking in wit, when seen handling a rope outside a suite of operating theatres, he replied that British surgeons visiting America had feared that Arbuthnot Lane might turn in his grave, but from what he had just seen a rope was needed to prevent Arbuthnot Lane from rising from his grave

The last day was spent in the Royal College of Surgeons of England Professor Wood Jones showed many of the treasures of the Hunterian Museum—the first madder experiments on bone growth, the injected placenta which maintains its colour as if prepared a few days ago, and the wonderfully preserved specimen of a cock's comb with implantation and survival of a human tooth A densely packed audience witnessed conferment of the Honorary Fellowship of the Royal College of Surgeons of England—a jealously guarded honour—upon Robert Harris of Toronto who, being made a Fellow of the College, was then able as Hunterian Professor to deliver a lecture on the problems of spondylolisthesis The American and Canadian guests were entertained to dinner in the Library, and on the tables were John Hunter's tankard, Cheselden's cup, Colles's silver, and other personal possessions of the great masters of surgery The unprecedented wearing by Lord Webb-Johnson, the President of the College, of his tartan waistcoat was matched by the wearing of tartan waistcoats by every single one of the visiting surgeons

As if the tour had not been exhausting enough the last Sunday was spent at House-in-the-Wood, where agreement in publication of a joint British-American Journal of Bone and Joint Surgery was reached Sunday—a day of rest indeed! A walking tour of the estate, the fighting of a forest fire, and the competitive felling of huge timber, was the order of the day Ted Dewar and Bill Bickel, with their Canadian and Minnesotan backwoodsmanship felled their tree first, Reg Watson-Jones and Scotty Law crashed theirs to the ground thirty seconds later Dinner was at the Royal Anchor Hotel, Liphook, renowned for the visits of Wellington, Nelson, Churchill, Eisenhower, and Canadian surgeons of Connaught Hospital

What shall be said of this venture? British orthopaedic surgeons who went to America last year cherish memories of their visit and will do so for the rest of their days This year, we in Britain have gained inestimable stimulus from the visit of surgeons from the North American continent We have learned to know each other Friendships, enduring friendships, have been established Long may they be encouraged

H OSMOND-CLARKE

SCOLIOSIS WITH PARAPLEGIA

K G McKenzie and F P Dewar, Toronto, Canada

From the Neurosurgical Division, and the Orthopaedic Division of the Department of Surgery, Toronto General Hospital

Our interest in the problem of scoliosis with paraplegia, excluding spinal deformities due to tuberculous disease, was aroused in 1925 when we operated on an eighteen-year-old youth who had severe scoliosis of the thoracic spine with motor and sensory involvement of the lower limbs and trunk (Fig 1) After surgical decompression of the spinal cord there was striking improvement This case was reported in 1927 and, since that time, four others have been added to our series these five, together with reports of comparable cases in the literature, make up a total of forty-one cases now available for study Most of these patients were males—which is odd, because orthopaedic surgeons are almost invariably impressed by the relative frequency of scoliosis in females The deformity was always in the dorsal spine, and as a rule there was a marked kyphotic element

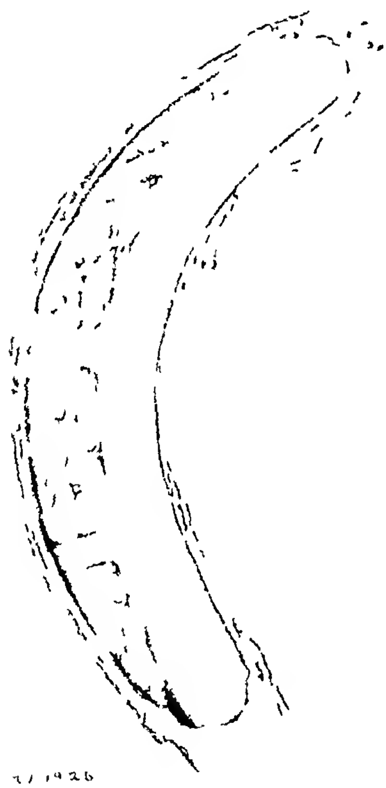


Fig 1

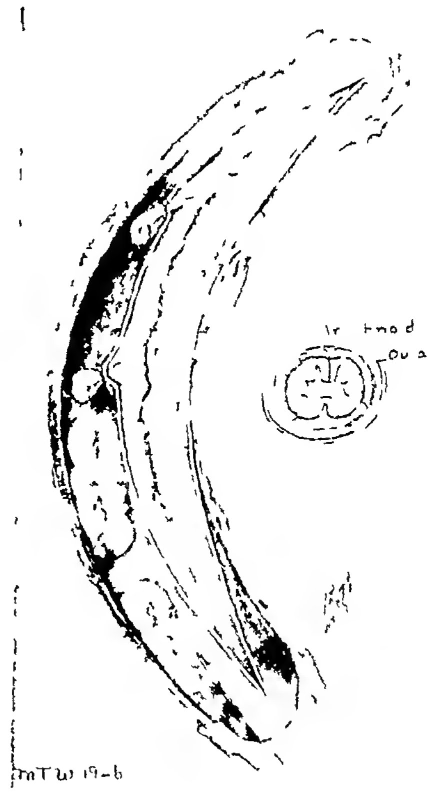


Fig 2

Case 1 S S The dural sac as it was exposed at operation (Fig 1) Herniation of the cord through the dural incision illustrates the importance of dividing the dura if pressure on the cord is to be relieved (Fig 2)

In all but eight cases the onset of symptoms due to interference with the spinal cord occurred between the ages of twelve and nineteen years Two patients were aged six years and six were twenty to twenty-three years of age With three exceptions, early evidence of cord damage heralded constant deterioration which usually terminated in profound motor and sensory loss but seldom in interference with sphincteric control The level of cord damage nearly always corresponded to the apex of the deformity—a fact which was demonstrated by intrathecal injection of lipiodol or pantopaque

There is no record of the treatment of three patients, one of whom died, twenty-four were at some period treated conservatively (though ten were operated upon later), and, in all, twenty-four patients were operated upon The most obviously successful results were gained by laminectomy, but in this group there were three post-operative deaths

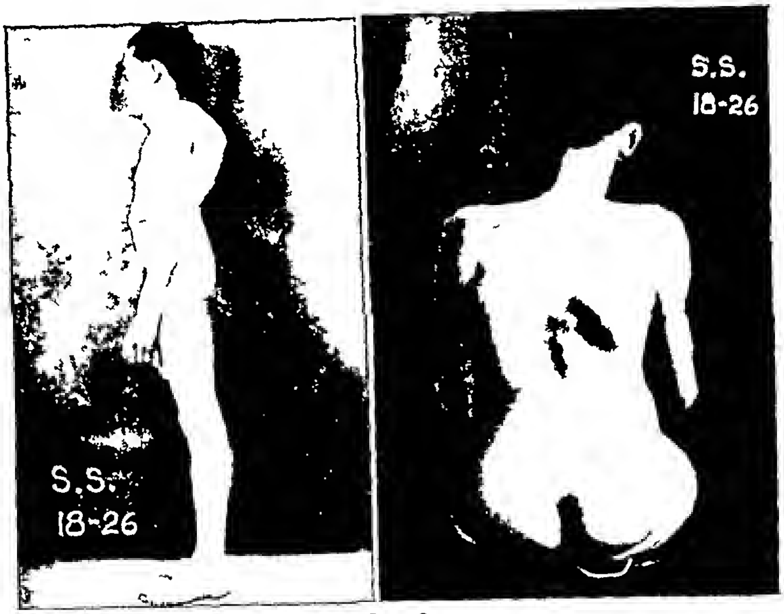


FIG 3

Case 1 S S Clinical appearances of the patient in 1926

FIG 4

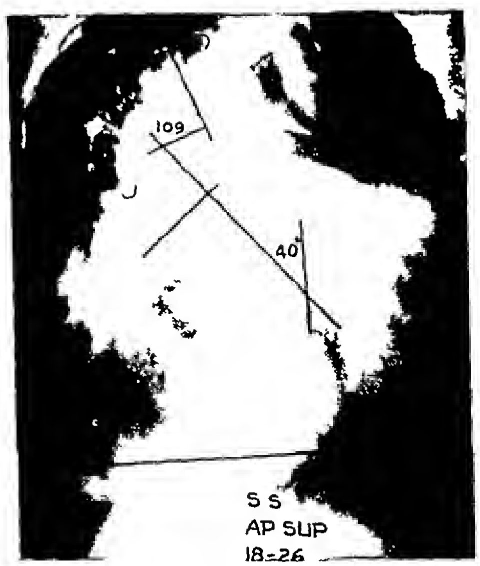
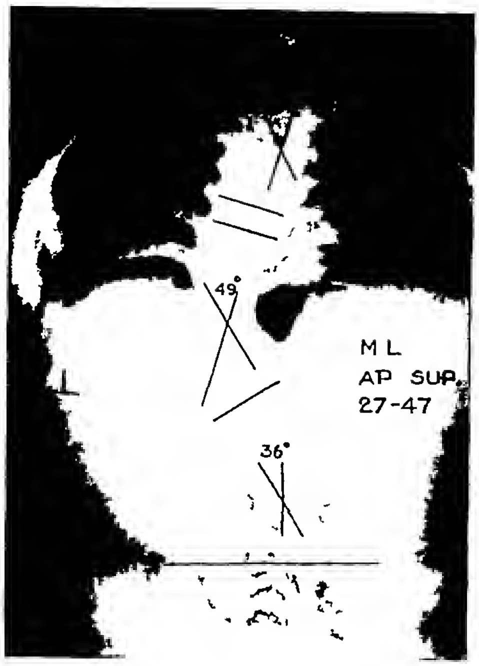


FIG 5

Case I S S Clinical appearances (Fig 3) and radiographic findings (Figs 4 and 5) as recorded in 1926 when the patient was eighteen years of age Severe kyphoscoliosis probably of idiopathic type measuring 109 degrees The lipiodol block is just above the apex of the curve at the seventh dorsal level (Fig 4) The curved lines shown in Fig 5 mark the extent of the laminectomy and the two silver clips indicate the point of maximal compression of the cord After an interval of twenty-one years there has been no appreciable increase in the curve

The paucity of case reports of scoliosis with paraplegia, and the fact that surgeons who see many patients with severe scoliosis have never seen one with paraplegia, indicates the rarity of the syndrome It seems clear that there must be some factor other than the deformity itself that accounts for paralysis



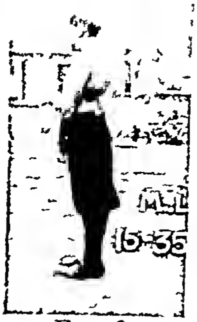


Fig 6

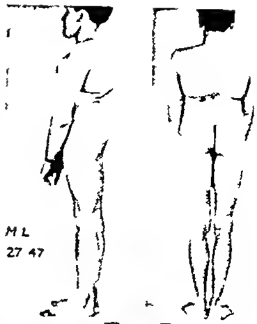


Fig 7

Fig 8

Fig 9

Fig 10

Case 2 M L The patient is seen as a boy aged fifteen years in 1935 (Fig 6) and as a man aged twenty-seven years in 1947 (Fig 7) The antero-posterior radiograph (Fig 8) taken in 1947 shows congenital deformities in both upper and lower dorsal regions of the spine Laminographic studies of the greater deformity (antero-posterior projection in Fig 9 and lateral projection in Fig 10) show a hemivertebra which is outlined The kyphosis measured 120 degrees and the block occurred at the apex

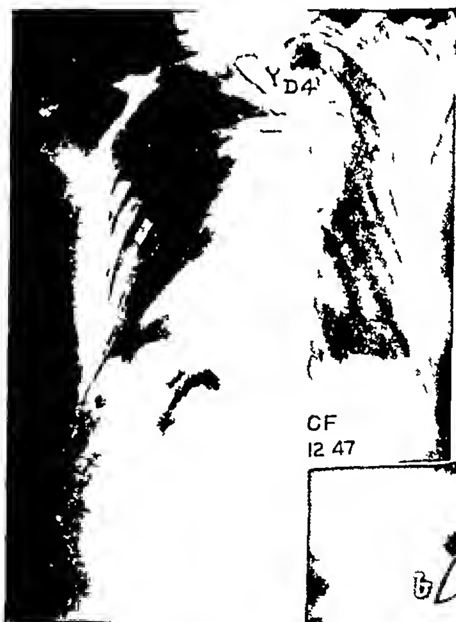


Fig 11

Fig 12

Case 5 C F Patient in 1947 aged twelve years is seen in Fig 11 The curve measured 80 degrees Laminographic studies showed its congenital nature with a hemivertebra and extra rib (Fig 12 inset) A myelogram showed the level of block at D 4 (Fig 12) and strikingly exposed the very eccentric relation of the cord to the vertebral bodies caused by the rotation and by the tight dural sac hugging the inner wall of the spinal canal

The problem has been reviewed again for a number of reasons 1) The operative findings in one patient were unique in our experience and, so far as we know, have not been described before (Case 3, Table I) In this unusual case a congenital band was stretched across the dural canal, and resection of the band cured the paralysis This case will be presented in detail 2) Since treating the first patient in 1925 we have operated on four others, and we are now in a position to speak with more certainty regarding the long-term prognosis 3) Technical points of the operation deserve mention 4) In previous reports there has been little discussion as to the type of scoliosis which may be associated with paralysis, whereas in our study this has been considered carefully 5) It was hoped, by careful review not only of our own cases but of others reported in the literature, that we might be able to determine the best method of handling these problems and elucidating their origin

CLINICAL MATERIAL

REPORT OF FIVE PATIENTS WITH SCOLIOSIS AND PARAPLEGIA

TABLE I

Case	Neurological findings	Date and type of operation	Result
Case 1 S S Male 18 years	Almost complete paraplegia with marked sensory loss coming on gradually over a period of two years	April 13, 1925 Dura left open	Excellent Normal neurological findings twenty-two years after operation
Case 2 M L Male 15 years	Unsteady spastic gait developing for six months Ankle clonus and extensor response to plantar stimulation No sensory disturbance Normal protein Arrest of lipiodol at T 5	April 11 1935 Dura left open	Twelve years later walks well good strength Slight increase in knee reflex Otherwise normal neurological findings
Case 3 R W Male 16 years	Barely able to walk Ankle clonus Up-going toes Marked sensory diminution in lower limbs and lower trunk Normal protein Incomplete arrest of lipiodol at area of greatest curvature	April 15 1941 Dura left open	Good Six years after operation, walks several miles without difficulty No sensory disturbance Still some stiffness of legs with clonus and up-going toes
Case 4 E I Male 29 years	Stiffness of feet—two months Unable to walk—six weeks Only slight flicker of movement in feet none in knees or hips Impaired sensation over lower limbs and trunk	August 8 1941 Dura left open	No improvement Seven years later evidence of syringomyelia of cervical cord confirmed at operation
Case 5 C F Female 12 years	Profound paraplegia with sensory loss coming on over a period of three months	November 5 1947 Dura left open	Discharged walking two months after operation Five months later able to run Excellent strength and co-ordination in lower limbs No ankle clonus Babinski negative Sensation practically normal

Case 1—S S—The first patient was operated upon in 1925 and was reported in detail (McKenzie 1927) The clinical appearances, and radiographs of the spine, are seen in Figs 3–5 The taut and narrowed dural canal and the marked release of cord pressure when the dura was opened are shown in Figs 1 and 2 Certain features of the operation which are believed to be important are discussed later (page 170) After operation there was rapid recovery from the motor paralysis and sensory disturbance which had progressed for two years and reached the point where the patient had been bedridden for two weeks When he was re examined in December 1947, twenty-two years after operation, there was normal muscle power in the lower limbs, no abnormality of reflexes, and no sensory disturbance in fact, the neurological picture was so normal that this was quite evidently the best result in our series of five patients

Case 2—M L, and **Case 5—C F** had operative findings comparable to those in Case 1 The essential points pertaining to these patients are shown in Table I

Case 4—E I—At the time of operation this patient with scoliosis and paraplegia showed no neurological signs above the level of spinal curvature Four years later, lower motor neuron signs and sensory disturbance developed in the upper limbs It was then found that he was suffering not from pressure paraplegia but from syringomyelia with congenital lesions of the cerebellar fossa—the Arnold Chiari syndrome The scoliosis was probably the result, and certainly not the cause of the neurological lesion

FIG 13

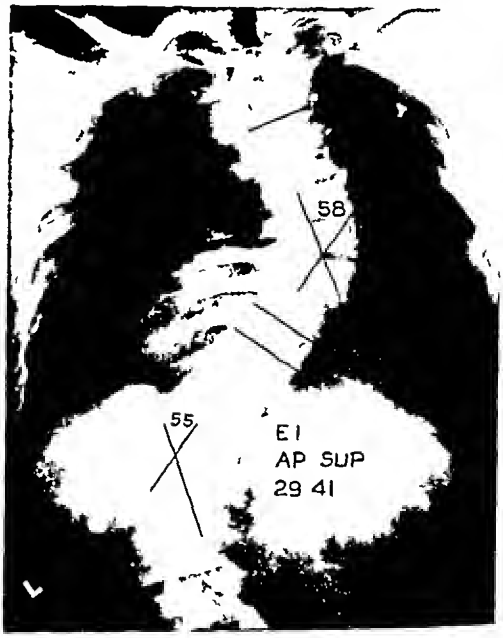


FIG 14

Case 4 E I A recent photograph shows the lower motor neuron atrophy above the scoliosis (Fig 13) This atrophy, together with sensory disturbance became apparent only four years after neurological signs had developed below the level of the scoliosis An antero-posterior radiograph (Fig 14) shows the nature of the curves The age, at the time of onset of paraplegia, was twenty-five years whereas the usual age of onset in this syndrome is in the neighbourhood of fifteen years With our present knowledge we feel that a diagnosis of compression of the cord by a tight dura associated with scoliosis in a patient of twenty-five years, especially if accompanied by such a radiographic picture would be unjustified and probably wrong

Case 3—R W, is reported in detail because the cause of paraplegia was quite different from that of other patients in this series and other cases recorded in the literature This sixteen-year-old boy was admitted to the Toronto General Hospital in August 1941 At the age of seven while riding a toboggan, he hurt his back, but within a few days he was well His birth and early development had been normal except that the left arm was always shorter than the right Two years before admission it was noticed that his back was not straight the right shoulder was more prominent than the left There was no history to suggest infantile paralysis or any acute infection

Clinical Examination—There was a dorsal scoliosis, convex to the right (Figs 15–17) with no weakness of the abdominal muscles which might suggest a paralytic origin For no obvious reason the left humerus was two inches shorter than the right *Neurological findings*—There was no weakness of any isolated group

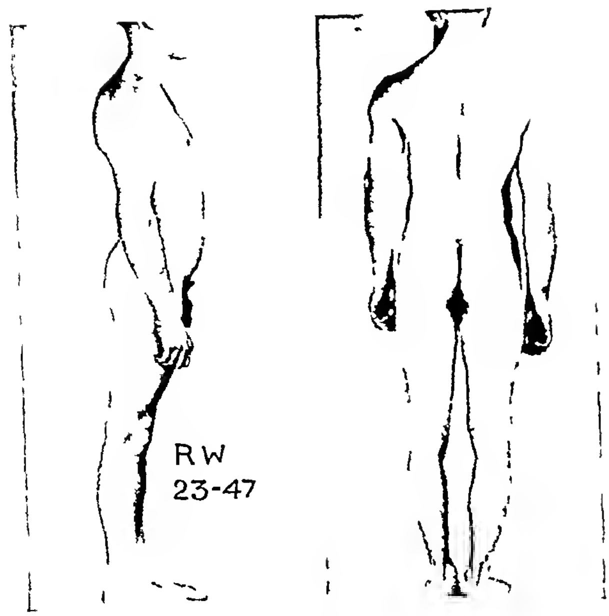


FIG 15

Case 3 R W Photograph in 1947 at the age of 23 years

FIG 16

FIG 17

Case 3 R W Photograph of the patient, at the age of twenty-three years, taken in 1947 shows that the scoliosis is not severe (Fig 15) This is confirmed in the antero-posterior radiograph taken in the standing position at the age of sixteen years in 1941 (Fig 16) The block to lipiodol occurred at the level of D 3 in the lesser curve which is not in accord with the findings in typical cases An antero-posterior radiograph taken in 1947 in the supine position (Fig 17) shows that there has been no increase in the curves Arrows point to silver clips which mark the cut extremities of the congenital band

of muscles such as might be expected in poliomyelitis. There was a marked spastic paraplegia. He was just able to get about with a stiff, shuffling gait which had come on gradually during the previous two or three months, and was first noticed in the right lower limb. There was general diminution of sensation over the lower limbs and trunk suggesting a lesion at about the second or third thoracic level, and precipitancy of urination. *Radiographic examination*—Comparison of radiographs taken at the age of sixteen years, and again at twenty-three years, showed no change in measurement of the spinal curves. Neither was marked: the left curve, extending from D 1 to D 4, measured 20 degrees, and the right curve, extending from D 4 to D 9, 30 degrees. There was no significant lumbar curve. A mild round-back was associated with the scoliosis. *Lipiodol myelography* disclosed an incomplete block at D 3. The findings were compatible with idiopathic scoliosis. The case did not fall into the usual group because the deformity was not severe. Lipiodol was put into the cistern, and it trickled slowly past the area of scoliosis showing that the block was not complete. Nevertheless we were able to satisfy ourselves that there was a marked and prolonged hold-up at the level of the second or third thoracic vertebrae, thus fitting in with the neurological findings.

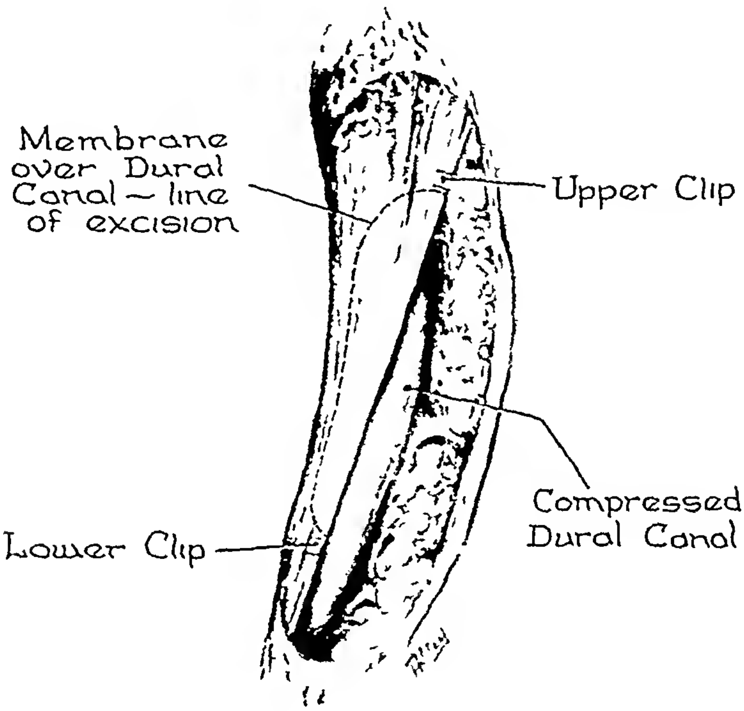


FIG. 18

Case 3. R. W. Illustration of the congenital membrane crossing the dural canal from side to side and compressing it. Marks indicate the line of excision of the band which was necessary to relieve pressure on the cord. After excision recovery of the paralysis was complete. It is possible that this band of developmental origin was the cause of the so-called idiopathic scoliosis.

Operation—(K. G. McK.) August 15, 1941—The surgeon's note made immediately after operation reads: "Laminectomy was done in the suspected region. The extradural fat, instead of being soft and easily handled as it normally is, proved to be very tough and interspaced with firm fibrous bands; it was at least one-eighth of an inch in thickness. When this was dissected away I was still confronted with an abnormal situation. There was a firm, extremely tight band of tissue stretched over the dural canal. Passing downwards this band cut across the dural canal to be anchored in the left lower part of the field. The band was about the thickness and consistency of dura; it was just as tight as a bow-string and undoubtedly was causing compression of the dural canal. Superficially this membrane had some light attachment to the overlying extradural fat. Where it was adjacent to the dura it was easily dissected or separated—by that I mean that it did not have any intimate connection with the dura, so that I think it is some

sort of congenital abnormality rather than inflammatory tissue The membrane was firmly anchored above and below beyond the operative bone defect This membrane was partly dissected out and I feel that we have completely removed the pressure on the dural canal Unfortunately, the specimen was lost, only the overlying extradural fat being saved for section If, however, the patient does not do well, further operation should be carried out higher up The dura was not opened Doctor Harris was called in to see this as I had never seen anything like it before We wondered if this abnormally tight band could have produced the scoliosis Two silver clips have been left in, they will show the upper and lower extent of removal of this band, and show its relationship to the scoliosis" (Fig 17) *Pathological Report*—The extradural fat showed no evidence of inflammation Unfortunately the band which was partly removed at operation was lost

Follow up Reports—Three weeks after operation the patient was discharged from hospital walking, with the sensory loss much improved *One year after operation*—Still walking with a stiff gait Able to stand on toes Numbness gone from legs No longer has precipitancy of urination Gait still improving *Six years after operation*—In good health, able to walk several miles without difficulty Definite stiffness and spasticity of the lower limbs especially the right All sensory disturbance has cleared up There is bilateral clonus more marked on the right and bilateral extensor response to plantar stimulation Subjectively the right leg is not as strong as the left, but each individual muscle group shows excellent strength neither dorsi-flexion nor plantar-flexion of the ankle can be overcome by the resistance of the examiner The residual neurological signs are presumably due to intrinsic damage to the spinal cord from prolonged interference with circulation, rather than to continued pressure

This case may represent no more than an unusual finding, not previously reported in the literature On the other hand, it may be of importance if similar lesions are found in other cases of idiopathic scoliosis Certainly the band was sufficiently strong and tight to have produced the scoliosis itself We believe that it was a developmental abnormality—possibly a remnant of the outer layer of dura which, in the spinal canal, is normally separated from the inner layer comprising the spinal dural canal At any rate we propose to look for such a lesion in a few cases of severe idiopathic scoliosis which are to be treated by spinal fusion with the object of preventing further progression of deformity It is possible that in some patients, such a lesion may be the cause of " idiopathic " scoliosis

COMMENTS ON THE RADIOGRAPHIC FINDINGS

Two facts became evident from our study of the radiographic findings in our own cases and those reported in the literature Almost without exception the paraplegia was associated with severe deformity, and in patients who were examined by myelography there was clear evidence of compression of the cord near the apex of the curve In earlier reported cases the etiology and type of scoliosis was often obscure, clinical description and radiographic reproduction being inadequate Many were described as congenital even although there was no substantive evidence other than the early onset and the marked wedging of apical vertebrae It seems probable, however, that most cases were in fact congenital in origin The second largest group was probably idiopathic in the modern sense of the word A few were attributable to infantile paralysis, some were associated with rickets, and two were examples of Von Recklinghausen's neurofibromatosis involving bone

There is little or no connection between the liability of a case of scoliosis to develop paraplegia and the origin of the scoliosis What is more important is the severity of the curve, and probably the rapidity of its development

COMMENTS ON OPERATIVE TREATMENT

In nearly all patients the cause of paraplegia is compression of the spinal cord by the dura This compression is relieved by opening the dura on the convex side of the curve The dural opening should be sufficiently long to uncover the deep sub-arachnoid spaces above and below (usually three to six inches) This is important in order to avoid nipping

of the cord if it should swell after operation The dura should be opened carefully so that there will be no tearing of the arachnoid If the arachnoid is opened, by mischance, pledgets of fibrin or gel-foam should be left over the area so that an accumulation of cerebro-spinal fluid between the exposed cord and the overlying muscles may be prevented In Case 1 of this series, in which the best result was gained, not only was the dura opened but two tight nerve roots were divided because it was thought that tension arising from them might interfere with the circulation of the cord For the same reason, it may sometimes be wise to cut several dentate ligaments On several occasions we have felt that adequate decompression necessitated lateral cuts, as well as a longitudinal cut in the dura Occasionally it may not be necessary to open the dura at all (as in Case 3 of this series—in which the compression was due to an extradural band)

The results of operative treatment—Of the forty-one cases that have been studied, twenty-four were treated by laminectomy—five of our own patients, and nineteen reported by others Three patients died two died within a few hours of operation, the exact cause of death being uncertain, one died several weeks after operation from decubitus ulceration and cellulitis Fifteen patients who were traced for more than seven months after operation made a recovery that could be classified as good or excellent, three gained only slight improvement, and three were not improved at all The six poor results warrant further study

(i) *Case reported in this series* (*Case 4—E I, Table I*)—At operation there was some doubt as to whether the dura was tight enough to be causing cord pressure Later, an ascending lesion of the cord proved to be due to syringomyelia associated with herniation of the cerebellar tonsils (Arnold-Chiari syndrome)

(ii) *Case reported by Elmslie* (1925)—A fourteen-year-old boy had neurological symptoms of two years' duration When the dura was opened it was apparent that the cord was squeezed in the usual manner Recovery was slow and the patient was just beginning to walk at the end of one year In view of the long duration of symptoms, delayed and incomplete recovery might have been expected

(iii) *Case reported by Grobelski* (1932)—In this patient, kyphoscoliosis was first associated with symptoms referable to the cord at the age of four to six years Progress was arrested by conservative treatment which was continued over a long period of time Nevertheless complete freedom of walking was never restored At the age of ten years, cord symptoms became prominent once more and the patient was bedridden in a few weeks Every type of conservative treatment was again tried and continued for three years Finally, at the age of thirteen years, laminectomy was performed The dura was very tight, and the cord was flattened and pale Two years later the condition was unchanged This patient had been profoundly paraplegic for three years before operation It must be concluded that, when definite neurological signs develop, decompression of the cord should not be delayed

(iv) *Case reported by Heuyer* (1944)—In a thirteen-year-old patient with cord symptoms of only three months' duration, deformity due to Von Recklinghausen's disease was short and sharp The dura was tight, and the cord was pale and thin No improvement was noted in the year after operation In this case there was no record of examination by myelography and it is possible that an extradural neurofibroma, elsewhere than at the site of operation, was missed It is also possible, however, in view of the pallid nature of the cord, that extreme pressure had produced irreversible damage

(v) *Case reported by Ruhlin and Albert* (1941—*Case* 3)—This was a patient, aged twenty one years, with cord involvement of nine months' duration and marked dorso-lumbar kypho-scoliosis After conservative treatment for twelve weeks, with some improvement, laminectomy and decompression of the cord was complicated by the development of a post-operative haematoma which had to be evacuated Three years later there was no improvement This case illustrates the importance, when the dura is opened and the spinal cord left exposed, of arresting all haemorrhage and leaving the operative field dry

(vi) *Case reported by Ruhlin and Albert* (1941—*Case* 4)—This case was also complicated by the formation of a post-operative haematoma requiring evacuation, again illustrating the importance of a dry field when the cord is exposed If a haematoma is suspected, because the neurological signs increase after operation, immediate exploration should be undertaken in order to prevent sustained pressure on the cord

Of the fifteen patients that did well the dura was left open in thirteen Recovery was complete in five, and in eight cases, despite residual spasticity, there was no complaint and the patients walked well It is reasonable to believe that irreversible changes in the cord occur with less frequency if operation is performed soon after the first appearance of neurological signs In two cases there was no reason to open the dura because the cause of obstruction was apparent —in one, a congenital band (Case 3, Table I), and in the other, a bone outgrowth, removal of which was followed by recovery (Heyman 1937)

The benefit gained from operation was clearly due to release of tension on the spinal cord by opening the dural sac It was usually noted that the cord herniated through the dural slit, and often that there was return of pulsation in the cord which previously had been absent Eleven of the patients with good results have been traced for more than one year after operation In the three cases of decompression reported in this series, which were traced for twenty-two years, twelve years, and seven years respectively, the improvement gained from operation was maintained and there was no evidence of recurrent symptoms It would seem that if decompression of the cord is successful, the long-term prognosis is assured

Decompression combined with spinal fusion—In only two cases reported in the literature was spinal fusion performed some months after decompression, presumably because there was fear of increased deformity and recurrence of cord symptoms (Heyman 1937, Ruhlin and Albert 1941) Such fear, however, is not substantiated by long-term results in our own cases and others reported in the literature Spinal fusion should not be combined with decompression at the initial operation because it increases the likelihood of haematoma formation Moreover, since the good results of simple decompression have been lasting, with no recognisable increase in deformity even when cases have been observed for many years, we believe that spinal fusion is seldom indicated even at a later date We would consider such a procedure only if there was definite evidence of increasing paralysis despite laminectomy, and this does not appear to be the usual consequence of the operation

COMMENTS ON CONSERVATIVE TREATMENT

Twenty-four patients were treated conservatively for varying periods twenty-three by traction and the application of plaster jackets and corsets, and one by spinal fusion without decompression of the cord In the case of spinal fusion the cord symptoms increased despite sound consolidation of bone (Ruhlin and Albert 1941) Of all the cases treated conservatively eleven were improved, in one there was temporary arrest in the progress of paralysis, and in twelve there was no change at all Of the eleven cases which improved, six were traced for eleven months or longer, and in five the clinical records are sufficiently complete to show that the late-result was good or excellent Of the twelve failures, ten were explored later with good results in eight, a poor result in one, and death in one

It is unfortunate that better records are not available in cases treated conservatively, for we find ourselves unable to make adequate comparison with operative methods There seems to be no doubt that in five cases there was remarkable improvement, and so far as we can tell the improvement was maintained It is to be noted, however, that relatively long periods of treatment were necessary in one instance there was no evidence of improvement for two months (Kleinberg 1923) and since we know that prolonged cord pressure may cause

permanent impairment of function, the treatment is perhaps dangerous unless there is evidence of recovery soon after treatment is started It was the lack of early response that prompted surgeons to perform laminectomy in ten cases which failed to show improvement after conservative treatment Furthermore, if paraplegia is not due to dural pressure, relief cannot be expected from conservative treatment, and this applies to the third case in this series where there was a congenital band (R W , Table I), and to the case reported by Heyman (1937) where the pressure was due to a spur of bone

In view of the facts that in skilled hands decompression of the cord is not a dangerous procedure, that there is often constricting pressure due to a tight dura, a congenital band, or a spur of bone, and that sustained compression of the cord may lead to irreversible changes causing permanent loss of function we must conclude that early laminectomy is advisable and that it should not be delayed too long

COMMENTS AS TO THE CAUSE OF PARAPLEGIA

Study of twenty-four cases treated by operation shows that, with the exception of three (bone block, congenital band, and syringomyelia), the cause of paraplegia was the combination of a tightly stretched dura and a sharply angulated spinal canal, the point of maximal pressure by the dura being localised at the angle of the spinal canal That the cord itself is not under longitudinal tension is borne out by the ready escape which may be observed at operation through the linear release incision made in the dura If then the cord is in fact compressed, which is established not only by the findings at many operations but also at two autopsies (Valentin and Putschar 1932, Thomas, Sorrel, and Sorrel-Dejerine 1933) the compression must be from the tightness of the dural sac The sac is attached more firmly to the foramen magnum above, and the sacrum below, than it is to the sides of the spinal canal by its prolongations on the nerve roots If it is taut, it will resist the tendency of the spinal cord to be displaced from a straight line by deformity, thus explaining localisation of the lesion to the apex of the curve The lumen of the dural sac must be narrowed still further by rotational displacement

It may be that in all cases of severe scoliosis there is some longitudinal dural tension, a degree that is usually insufficient to cause symptoms but is ready nevertheless to respond to anything which might tip the scales This was suggested by Jaroschy (1928) who demonstrated by intrathecal lipiodol an incomplete block at the apex of the curve in two patients whose scoliosis was not associated with paraplegia It is corroborated in the case reported by Grobelski (1932)—a young patient, in whom neurological symptoms first appeared at the age of six years progress in the neurological symptoms was arrested by conservative treatment, and over a period of four years there was neither improvement nor deterioration, at the age of ten years distortion of the spinal column increased rapidly and was accompanied by increased difficulty in walking, within a few weeks paraplegia was complete

It seems probable that in these rare cases of scoliosis with paraplegia the exciting cause which precipitates paralysis is the rapid growth of the spinal column together with the inability of a tight dura to accommodate itself to such growth In all but six of the forty-one cases that have been reported, the age at which there was recognition of abnormal neurological signs corresponded to the years of most rapid growth One exception is explained by the final diagnosis of syringomyelia (Case 4, this series), and, in a second case, doubt may be cast on the validity of diagnosis because the cord symptoms showed many remissions and no steady progress (Roger and Schacter 1940) In the few cases in which paraplegia first developed in later years, after growth had ceased, the precipitating cause is obscure, but some light may perhaps be thrown on this matter by future observations at operation and autopsy

SUMMARY

1 Five cases of scoliosis with paraplegia are reported, and thirty-six comparable cases from the literature are reviewed These forty-one cases have been studied with the object of determining the etiology of scoliosis, the reason why cord compression sometimes develops, and the results of conservative and operative treatment of such compression of the cord

2 The cause of paraplegia is nearly always compression of the spinal cord by the dura, which, in severe scoliosis, is under longitudinal tension because of its firm attachment to the foramen magnum above and the sacrum below Such tension, resisting displacement of the spinal cord from the straight line, may be shown to cause incomplete spinal block even when there is no paralysis

3 When paralysis occurs it usually develops during the years of most rapid growth, the tight dura being unable to accommodate itself to the rate of growth of the spinal column, cord compression is probably increased by narrowing of the dural sac by rotational displacement

4 The most striking results have been secured by laminectomy with section of the dura and sometimes division of dentate ligaments and tight nerve roots After such division there is evidence of release of compression the cord herniates through the dural slit, and spinal pulsation returns

5 It is important to control bleeding in order to avoid post-operative compression by blood clot, and to prevent leakage of cerebro-spinal fluid through the arachnoid

6 It is unwise to perform spinal fusion at the same time as decompression because it increases the danger of haematoma formation Moreover the improvement gained by decompression is maintained even if no fusion of the spine is performed

7 Conservative treatment of scoliosis with paraplegia should not be continued for long periods unless there is evidence of early and progressive improvement because prolonged compression causes irreversible changes in the cord

8 In three cases, paraplegia was not due to dural compression one turned out later to be a case of syringomyelia, one, reported by Heyman, was due to the pressure of a bone spur, and one, reported in this series, was due to a congenital tight band of developmental origin which might have caused the scoliosis as well as the paralysis, and in which, after resection of the band, recovery from the paralysis was complete

DISCUSSION

Dr Arthur Steindler (Iowa City Iowa)—This series of cases of paraplegia in scoliosis is a valuable and most welcome addition to our knowledge As the speakers have indicated earlier reports of this complication were indeed scarce Since the first description by Mauclaire in 1913, and the report by Ridlon in 1916, there are hardly two score cases on record From our clinic in Iowa City Ruhlin and Albert reported seven cases five being treated by laminectomy Our oldest observation goes back to 1915 and it concerned a boy aged ten years with a severe dorso-lumbar curve and a marked degree of rotatory deformity Spastic paraplegia was progressive and it did not yield to conservative treatment though temporary improvement was gained by traction Laminectomy was refused Another case treated by fusion alone without laminectomy likewise showed no improvement in the degree of paralysis though the fusion remained solid Of the five cases that were dealt with by laminectomy after unsuccessful conservative treatment one died shortly after operation from pneumonia and the other four were greatly improved or recovered completely

The pathological findings were of interest *Case* 1 (*H C*) had a pulsating cord with no direct pressure but there was distinct tension on the cord due to kinking One month after operation there was clinical improvement in sensory findings and no abnormality of reflexes *Case* 2 (*I S*)—There was a question of neurofibromatosis Laminectomy from the seventh cervical to the sixth dorsal level showed a pulsating cord but with a definite kink After operation all symptoms were exaggerated but improvement began three months later, including improvement in bowel and bladder function *Case* 3 (*M L*)—Severe right

thoracic curve Laminectomy from third to seventh thoracic vertebrae, distinct kink at fifth rapid improvement, complete recovery after three months *Case 5 (C N)*—Severe left cervico-thoracic curve Laminectomy fourth cervical to fifth dorsal vertebrae pulsation absent but returned after decompression severe kink at apex Under observation for more than two years, marked improvement but not complete recovery

The most interesting feature in the series reported by Dr McKenzie and Dr Dewar is the finding of a congenital band in one case This conforms with the observation that most of these cases of scoliosis are of the congenital type One wonders if the mechanical factor alone is responsible or whether congenital anomalies have anything to do with the production of paralysis So far as the pathomechanics are concerned, we believe that torsion of the cord is a more important cause of ischaemia than direct compression How much distortion will the cord tolerate? And why does paralysis appear so seldom in severe scoliosis? In our series it developed in less than 0 3 per cent of cases Many questions remain unanswered But the careful study of the authors cases has furnished an important contribution to our knowledge and I deem it a privilege to be permitted to discuss their paper

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POLYOSTOTIC FIBROUS DYSPLASIA—ALBRIGHT'S SYNDROME

A Review of the Literature and Report of Four Male Cases, Two of which were associated with Precocious Puberty

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Polyostotic fibrous dysplasia is a rare disease of the skeleton Despite much speculation the etiology remains obscure At this stage of our understanding of the disease, which is of interest to physicians, pediatricians, radiologists and orthopaedic surgeons, it is desirable that a detailed record of new examples should be made as they arise

NOMENCLATURE

Lichtenstein (1938) introduced the term polyostotic fibrous dysplasia to designate " a skeletal developmental abnormality affecting one, several, or many bones with a predominantly unilateral distribution " Reports of similar cases had occurred before, but under a bewildering variety of titles

Some cases, with widespread skeletal lesions, also show other changes Albright, Butler, Hampton, and Smith (1937) described the association of predominantly unilateral skeletal changes with pigmentation of the skin, and with precocious puberty in females This syndrome now bears Albright's name The first recorded case appears to be that of Weil (1922) Recently Dockerty, Ghormley, Kennedy and Pugh (1945) analysed thirty-three cases from the literature and added six of their own

CLINICAL FEATURES

The condition is a disorder of childhood which becomes arrested in adult life The sexes are affected equally The expectation of life is not diminished, but deformities and pathological fractures are common In addition to the features which characterise Albright's syndrome, polyostotic fibrous dysplasia may be associated with other endocrine changes Enlargement of the thyroid gland was found in five of twenty-five cases extracted from the literature of the previous decade by Falconer and Cope (1942), two of these had thyrotoxicosis These authors also reported two cases of widespread bone disease with non-toxic enlargement of the thyroid gland and some manifestations of acromegaly Peck and Sage (1944) reported a case in which there was toxic goitre with acromegaly, and diabetes mellitus from which the patient died

In addition to endocrine changes, certain congenital abnormalities have been observed, but their association may be fortuitous Stauffer (1941) described a case with arteriovenous aneurisms Osgood (1946) reported a patient in whom the dysplasia co-existed with osteopoikilosis but other manifestations of Albright's syndrome were not present Two cases are on record in which the osseous dysplasia was accompanied by multiple soft tissue tumours Uehlinger (1940) recorded the case of a man who died at the age of sixty-seven and had suffered, since childhood, from widespread fibrous dysplasia of the skeleton with multiple soft tissue tumours of similar histological appearances to those of the affected bones

Sexual precocity in the male has seldom been observed, indeed as recently as 1947, Bogart and Imler stated that precocious puberty was limited to female cases Lange (1938), and Falconer and Cope (1942), reported precocious puberty in two boys aged eight and ten years respectively Two of the four cases reported in this article, all of which were males,

developed secondary sex characters during the first decade In contrast to sexual precocity is the case of Moehlig and Schreiber (1940) where a boy of sixteen with multiple bone lesions had no beard, or axillary hair, he had pubic hair of female distribution, and a puerile voice

RADIOGRAPHIC APPEARANCES

Radiographic features of the dysplasia consist of multiple localised lesions with normal bone elsewhere According to the distribution of the affected bones the disease may be monostotic, monomelic, unilateral, or bilateral The vertebral column is seldom affected Areas of rarefaction and expansion are often found which, in the radiographs, resemble true cysts The affected bones show a " ground glass " appearance in which homogeneous areas of increased or decreased density are present with thinning of the overlying cortex The epiphyses are seldom affected, and then only after union with the shaft Fusion may, however, occur prematurely The base of the skull often shows enormous hypertrophy of dense bone which may obliterate the nasal sinuses and compress the cranial nerves Great thickening of the calvarium, often resembling the changes of Paget's disease and especially when involving the base of the skull, may present a striking feature which is of diagnostic importance In some bones there is only slight coarsening of trabeculation, but it is reasonable to suppose

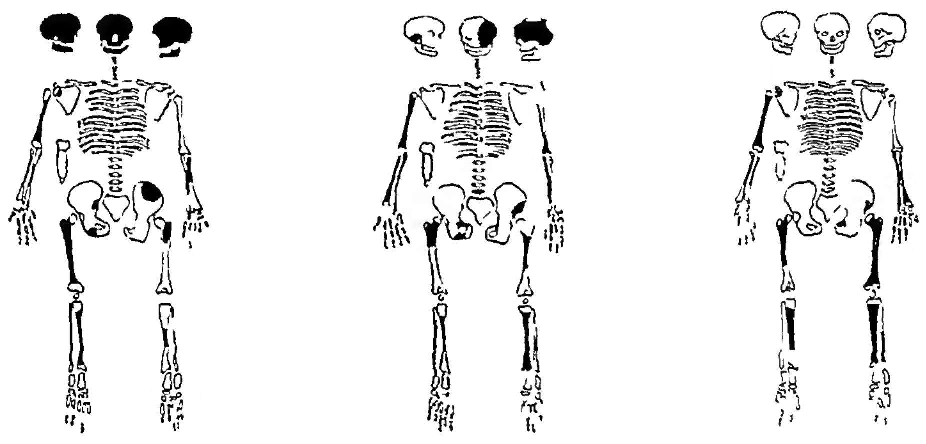

FIG 1

Diagrams to show the distribution of skeletal lesions as disclosed by radiographs in a male patient aged twenty-five years, a boy aged eleven years, and a boy aged thirteen years

that in these questionable areas the pathological process is not yet so advanced as to have established radiological evidence Albright *et al* (1937) drew attention to similarity between the radiographic appearances of fibrous dysplasia and healing parathyroid osteodystrophy after parathyroidectomy

PATHOLOGY

The skeletal changes have been described by Albright *et al* (1937), Uehlinger (1940), Lichtenstein and Jaffe (1942), and Falconer and Cope (1942) Uehlinger stated that the marrow spaces are the site of proliferation of relatively avascular and acellular fibrous tissue which leads to expansion and thinning of the cortex The long bones and the neighbouring bones of the limb girdles are most often affected and the " shepherd's crook " of the femur —a coxa vara deformity—is characteristic The disease affects primarily the diaphysis it is exceptional for the epiphyses to be affected True cysts, giant-cell tumours, inflammatory changes, and neoplastic changes, do not occur The base of the skull and the bones of the vault are often the site of gross changes which have recently been described by Windholz (1947)

in a paper in which the relationship between fibrous dysplasia and leontiasis ossia is discussed

Blood chemistry—No constant changes are found in the blood chemistry other than elevation of the alkaline phosphatase if the bone changes are widespread

ETIOLOGY

The etiology of the skeletal and extraskeletal changes is not understood The most recent comprehensive surveys of current ideas are to be found in the monographs of Furst and Shapiro (1943), Falconer and Cope (1942), and Dockerty *et al* (1945) Falconer and Cope suggested that the association with polyostotic fibrous dysplasia of endocrine disturbance and cutaneous pigmentation was one of independent variables, and that the distinction between the dysplasia on the one hand, and Albright's syndrome on the other, was one of degree They believe that a common etiological basis must exist because the features of Albright's syndrome occur with such frequency in cases showing disseminated bone lesions It is generally accepted that the disease must be due to a disturbance of undifferentiated mesenchyme in early embryonic life Heredity appears to play no part The only convincing example of a familial incidence was that of Hirsch (1929) where three siblings were affected Several cases have been described in which icterus gravis neonatorum had occurred (Braid 1939), but these constitute a very small proportion of the recorded cases and it seems unlikely that the association is of significance

DIFFERENTIAL DIAGNOSIS

Polyostotic fibrous dysplasia may be confused with hyperparathyroidism, Paget's disease, Ollier's disease, osteogenesis imperfecta tarda, and the lipoid reticuloses In monostotic cases a number of other conditions will have to be considered, amongst which are neurofibromatosis and osteoclastoma

Hyperparathyroidism is characterised by general skeletal decalcification and typical changes in the blood calcium and phosphorus levels, high alkaline phosphatase, and increased excretion of calcium

Paget's disease is rare under the age of forty years and is usually associated with thickening of cortical bone The only close resemblance with fibrous dysplasia is in the changes which occur in the calvarium

Ollier's disease (skeletal enchondromatosis) shows sharply defined lesions in the cartilage bones which are usually short with broad and irregular metaphyses

Xanthomatosis and Gaucher's disease are likely to present other stigmata such as the manifestations of Hans-Schuller-Christian's syndrome in the first disease, and splenomegaly in the other, with characteristic appearances in the marrow film obtained by sternal puncture

Osteogenesis imperfecta tarda may resemble fibrous dysplasia in the history of repeated fractures and in the ground-glass appearance of the bones in radiographs It differs in that there may be a family history of the condition, the bones are usually slender and often decalcified, the manifestations in the skull are different, and the vertebral bodies are flattened

TREATMENT AND PROGNOSIS

Polyostotic fibrous dysplasia does not reduce the expectation of life Fresh lesions cease to appear when maturity is reached No medicinal therapy has been found to have any effect upon the disease, and treatment is necessarily limited to the management of fractures and deformities

CASE REPORTS

Case 1 J M, barber, aged twenty-five years (Figs 1–8) had walked with a limp since the age of eight He sustained a pathological fracture of the left femur when aged eleven At intervals since then he has suffered fractures of the right femur, left radius left ulna and left humerus At the age of thirteen his voice broke and secondary sex characteristics appeared There was no history of icterus neonatorum and no relevant family history

FIG 2

FIG 3

Case 1 There is deformity of the right upper and lower jaws and palpable bosses above the hairline (Fig 2) The right mandible is expanded and shows mottled areas of rarefaction and sclerosis

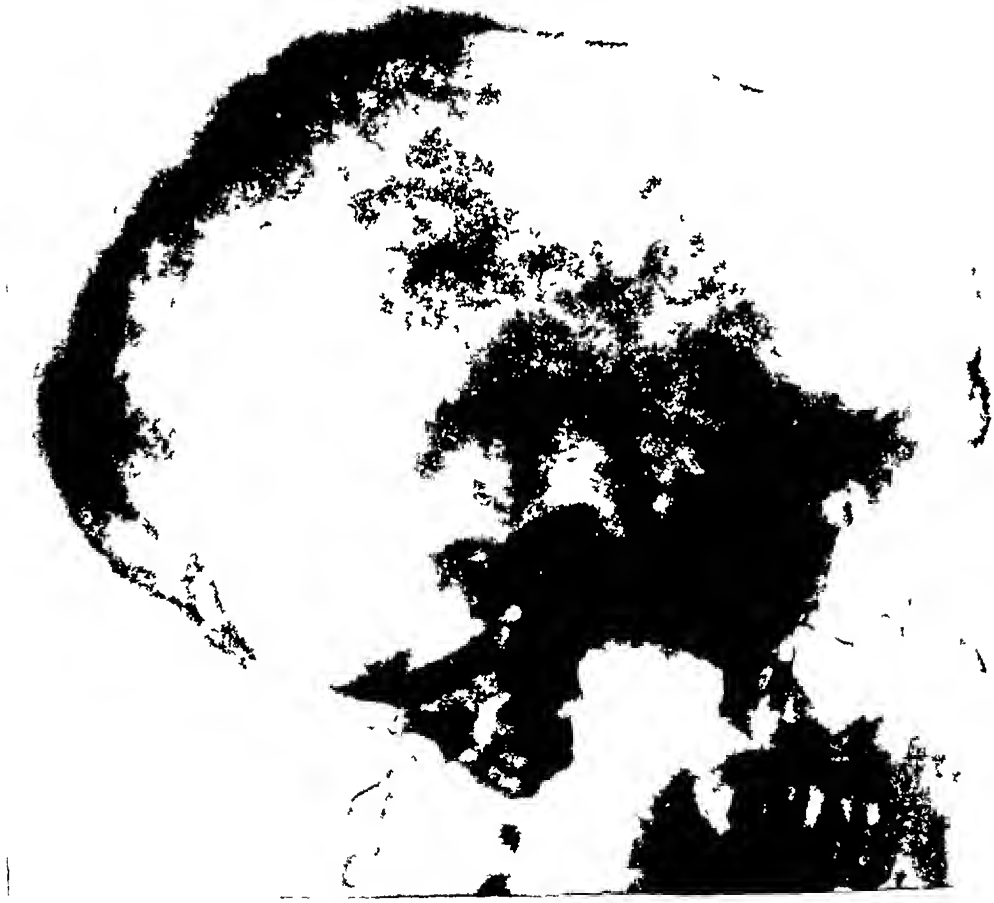

FIG 4

Case 1 There is much thickening of the parietal bones and hyperostosis of the base of the skull

On examination he exhibits marked facial asymmetry and deformity of the left mandible (Fig 2) There is a patch of brown pigmentation in the lumbar region The left leg is shorter than the right There are visible and palpable irregularities of the ribs He has a large "cyst" in the right humerus which is fractured in two places (Fig 7), but despite this, he is able to continue his work with no support for the limb

FIG 5

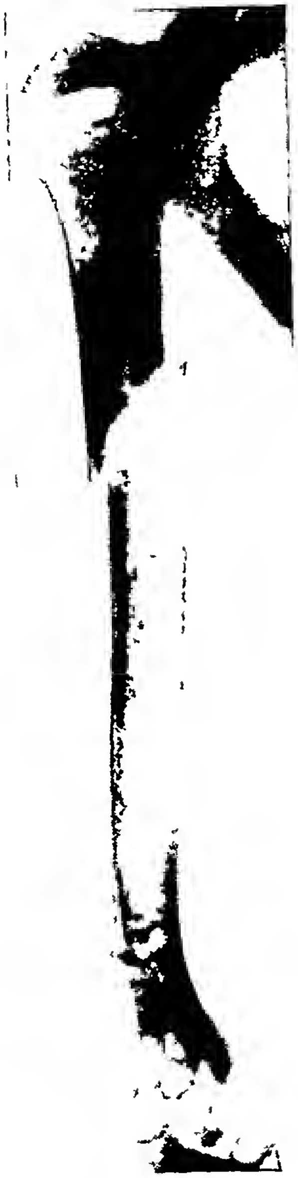

FIG 6

FIG 7

Case 1 The right humerus at the age of eleven years (Fig 5) At the age of fourteen years a fracture of the upper shaft of the bone was sustained (Fig 6) At the present time the patient is aged twenty-five years, and despite the fact that two fractures have now been sustained and that the bone shows very extensive 'cystic changes and expansion of the shaft no external support is needed and the patient continues his work as a barber (Fig 7)

Blood chemistry (November 1947)

Calcium	9 0 mgm per 100 c c
Phosphorus	2 2 mgm per 100 c c
Urea	43 mgm per 100 c c
Alkaline phosphatase	17 4 units (Jenner and Kay)
Urea concentration test	3 55 per cent
Urea clearance test	80 per cent of normal

Radiographic appearances—The distribution of skeletal lesions is shown in the diagram (Fig 1) The skull shows gross changes in the calvarium which simulate Paget s disease (Fig 4), and marked hypertrophy

of the base, the mastoid processes and the sphenoid bone The bones show a typical " ground glass " appearance but there are many " cystic " areas in the ribs, the right humerus, and the right femur The " shepherd's crook " deformity of the right femur developed between 1934 and 1936 (Fig 8) Gross changes in the right humerus have occurred in the last ten years (Figs 5–7)

Comment—This case exhibits bone changes typical of polyostotic fibrous dysplasia, and there is a patch of cutaneous pigmentation, but the third stigma of Albright's syndrome—sexual precocity—is lacking

FIG 8

Case 1 Hip joint and upper shaft of the femur at the present time (patient aged twenty-five years) There is a typical " shepherd's crook " or coxa vara deformity

Case 2 J M , schoolboy, aged eleven years, has since the age of three years sustained three fractures of the left tibia and fibula, a fracture of both femora, and a fracture of the left radius and ulna Two years ago a " cyst " of the left femur was curetted and bone chips were inserted Since birth he has had a patch of brown pigmentation over the posterior aspect of the right shoulder and arm At the age of eight years his voice broke and pubic hair appeared There is no history of icterus neonatorum and no relevant family history *On examination* he appears older than his years His height is 5 feet 11 inches and weighs just over 7 stones (99 pounds) There is prominence of the left frontal and parietal regions The thyroid gland is not enlarged The genitalia appear to be mature His physical appearance is shown in Fig 9 *Blood chemistry* Calcium 10 9 mgm per 100 c c Phosphorus 3 3 mgm per 100 c c Alkaline phosphatase, 51 0 units (Jenner and Kay) Urea 35 0 mgm per 100 c c
Radiographic appearances—The distribution of skeletal lesions is shown in the diagram (Fig 1) The affected bones are irregularly expanded and show a " ground glass " appearance as well as " cystic " areas

The epiphyses of his elbows suggest some precocity since fusion of the capitellum and trochlea with the humeral shaft is almost complete The skull exhibits great thickening of the left parietal and both mastoid regions the left halves of the middle and anterior cranial fossae show similar gross changes and the sphenoid sinus is obliterated (Fig 10) The left ethmoid and maxilla are also involved The left femoral neck

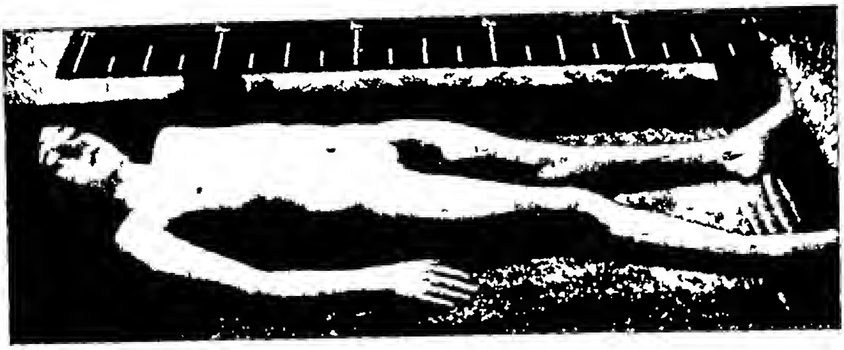

FIG 9

Case 2 Physical appearance of the boy aged eleven years Puberty occurred at eight years of age

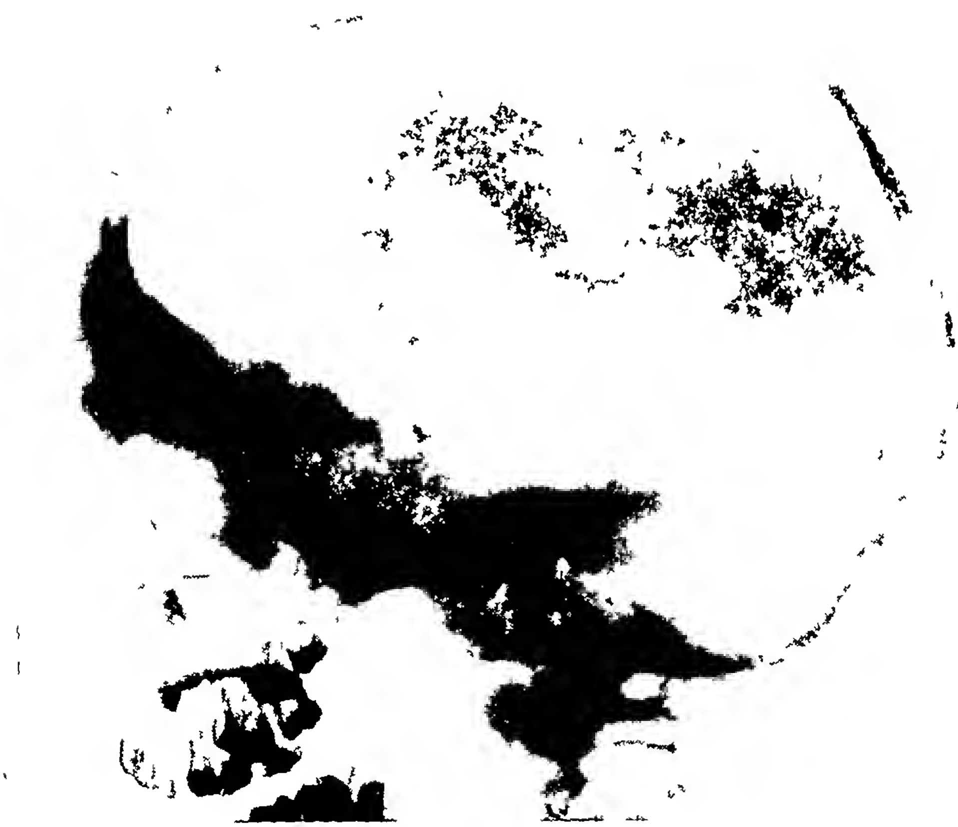

FIG 10

Case 2 Lateral radiograph of the skull shows the enormous hyperostosis of the base

and upper part of the shaft are "cystic" but although there is a symptomless pathological fracture there is not yet coxa vara deformity In this case the insertion of bone chips does not seem to have led to ossification of the abnormal area

Comment—This case presents a typical radiological picture of polyostotic fibrous dysplasia and the bone changes are also associated with cutaneous pigmentation and precocious puberty

Case 3 A T, schoolboy, aged thirteen years, was admitted with a fracture of the shaft of the left femur sustained while boxing There was no history of previous fractures but since the age of seven cramp-like pain has been felt occasionally in the left thigh There is no history of icterus neonatorum and no relevant family history *On examination* he is a small healthy looking boy, height 4 feet 10 inches, weight 5½ stone (77 pounds) There is extensive pigmentation of the right leg, thigh, and buttock Secondary sex characteristics have not yet appeared

Blood chemistry

Calcium	10 7 mgm per 100 c c
Phosphorus	3 2 mgm per 100 c c
Alkaline phosphatase	25 7 units (Jenner and Kay)
Urea clearance test	43 per cent repeat=59 per cent of normal
Urea concentration test	2 76 per cent repeat=2 9 per cent of normal
Calcium balance test	Normal

The tests suggested some impairment of renal function but there was no albuminuria, and intravenous pyelography showed no abnormality

Radiographic appearances—The distribution of the lesions is shown in the diagram (Fig 1) They consist almost entirely of areas of expansion where the cortex is thin, and the normal architecture is replaced by the structureless ' ground glass ' appearance The skull is unaffected There is mild coxa vara deformity of the left femoral neck where little normal bone is visible but on the right side there is a bridge of normal bone in this position and no coxa vara Most of the affected bones show uniform increase in breadth

Comment—This case shows widespread skeletal involvement, bilateral in distribution, with cutaneous pigmentation but no other apparent abnormalities

Case 4 T W, male, aged sixteen years—At the age of three months pigmentation of the buttocks and right thigh was noticed and at five years of age facial deformity became evident In 1942, when he was ten, he was examined by Dr Court who observed that the skull and face were large and deformed the hands and feet large and the size of the right upper limb greater than that of the left There was sexual and skeletal precocity His genitalia were pubescent and he was tall for his age

Blood chemistry (1942)—

Serum calcium	10 4 mgm per cent
Serum phosphorus	3 3 mgm per cent
Blood urea	21 mgm per cent
Urea clearance	145 per cent normal
Plasma cholesterol	119 mgm per cent
Alkaline phosphatase	43 units
Urine	Normal
Glucose tolerance test	Normal
Blood W R and Kahn tests	Negative
Rh positive (in 1944)	

Ophthalmological examination—Normal

Radiographic appearances (1948)—The left fourth and seventh ribs are abnormal in shape and structure, showing no differentiation between the cortex and medulla and no trabeculation The base of the skull shows marked hyperostosis The squamous part of the occipital bone is expanded, and the maxillae are so grossly affected that the antra are almost completely obliterated The mandible is expanded, especially on the left side, and normal trabeculation is replaced by the homogeneous " ground glass ' appearance of fibrous dysplasia No convincing changes are seen in the rest of the skeleton

Comment—This case shows characteristic bone changes affecting the skull and two ribs No " cysts " are present in any bones The skeletal precocity is perhaps evidence of endocrine disturbance, and the presence of a large area of pigmentation affords additional evidence by which to support the diagnosis of Albright's syndrome (This patient has been under the care of Dr Court for four years and has been investigated by Dr Donald Hunter who established the diagnosis of Albright's syndrome)

SUMMARY

1 Four cases of polyostotic fibrous dysplasia are presented

2 All are males, all show cutaneous pigmentation, and in two there has been precocious puberty

3 The literature has been reviewed, and present conceptions of the pathology and etiology of the disease have been discussed

4 The dysplasia if often confused with parathyroid osteodystrophy and sometimes the parathyroid glands are needlessly explored This confusion should not arise if it is remembered that no general skeletal decalcification, and no constant changes in the blood calcium or phosphorus, occur in polyostotic fibrous dysplasia The radiographic appearances of healing parathyroid osteodystrophy are, however, indistinguishable

5 No effective therapy has been discovered for this disease Pathological fractures and deformities may require treatment

I must express my thanks to Professor Nattrass Mr Gordon Irwin, and Mr Jones, of the Royal Victoria Infirmary Newcastle upon Tyne and to Mr Reid of Middlesbrough for permission to publish these cases I have also to thank Dr Donald Court for much helpful criticism the staff of the Hospital for Sick Children for the opportunity to study radiographs of Case 4 and Mr E Forster for his help in the preparation of illustrations

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TYPES OF DISPLACEMENT IN FRACTURES OF THE FEMORAL NECK

and Observations on Impaction of Fractures

PER LINTON, GAVLE, SWEDEN

From the Service of the Central Hospital, Gavle

In fractures of the femoral neck there may be displacement of different types accounting for the well recognised abduction and adduction fractures with valgus and varus displacement (Nystrom 1938) Between these types there is a transitional form that was described by Waldenstrom (1924) as the "fracture impacted in adduction" and by this author as "the intermediary type" (Linton 1944) The title intermediary fracture, which was intended to emphasize the mid-position of displacement between abduction and adduction, has been criticised because the term "*medial fracture*" has already passed into general use as an indication of the level of injury in the femoral neck, a medial fracture being the equivalent of an intracapsular fracture In the German language intermediary fractures would be described suitably as *Ubergangsfrakturen*, but it is difficult to find a comparable term in English This type of displacement is of great significance, and insufficient attention has been paid to it in the literature The fact that it does indeed exist calls for emphasis

Figure 1 illustrates the displacements in five fractures of the femoral neck It is evident, from this manner of presentation, that they form a graduated series All radiographs in the upper row have been taken in the frontal plane and they range from the first, which shows no displacement, to the second which shows valgus displacement, the third which shows the intermediary position, the fourth in which there is an incipient varus position, and finally to the fifth in which there is such varus displacement that the fragments have slipped apart An increasing degree of outward rotation of the femoral shaft is evident in the progressive prominence of the lesser trochanter The lateral projections, illustrated in the lower row, show clearly how this recurvation has increased steadily as we progress from the first to the fifth type These radiographs, selected from different patients, and showing in each case the primary displacement, illustrate *different stages in the displacing movement beginning with a valgus position and passing, under increasing recurvation, into a varus position*

In adduction fractures the fragments are not actually in varus relationship to each other The fact is that the peripheral fragment is rotated outwards, round the longitudinal axis of the femur, while the neck is directed forwards so that the femoral head lies on its posterior aspect This is shown in Fig 2 All outlines in the upper row show the femoral shaft in an unchanged position, displacement of the femoral head occurs progressively backwards and downwards on the posterior aspect of the neck This dislocating movement is the same as in Fig 1, though the projection of the pictures is different Thus, neither the term "adduction fracture," nor "varus fracture," can be considered adequate if it is intended to denote the mutual position of the fragments

In a review of 323 fractures of the femoral neck in which the direction of original displacement was known and analysed by this writer (Linton 1944), forty-seven were abduction fractures (14 6 per cent), twenty-eight were intermediary fractures (8 6 per cent), and two hundred and forty-eight were adduction fractures (76 8 per cent) That these three types of fractures, each with different displacement, were due to different types of injury is often assumed, and if we are to judge from the literature such a conception is widely entertained Nevertheless, it is probably incorrect and the assumption has been made too readily In support of this contention, which was first discussed in the author's article of 1944, certain observations may now be made

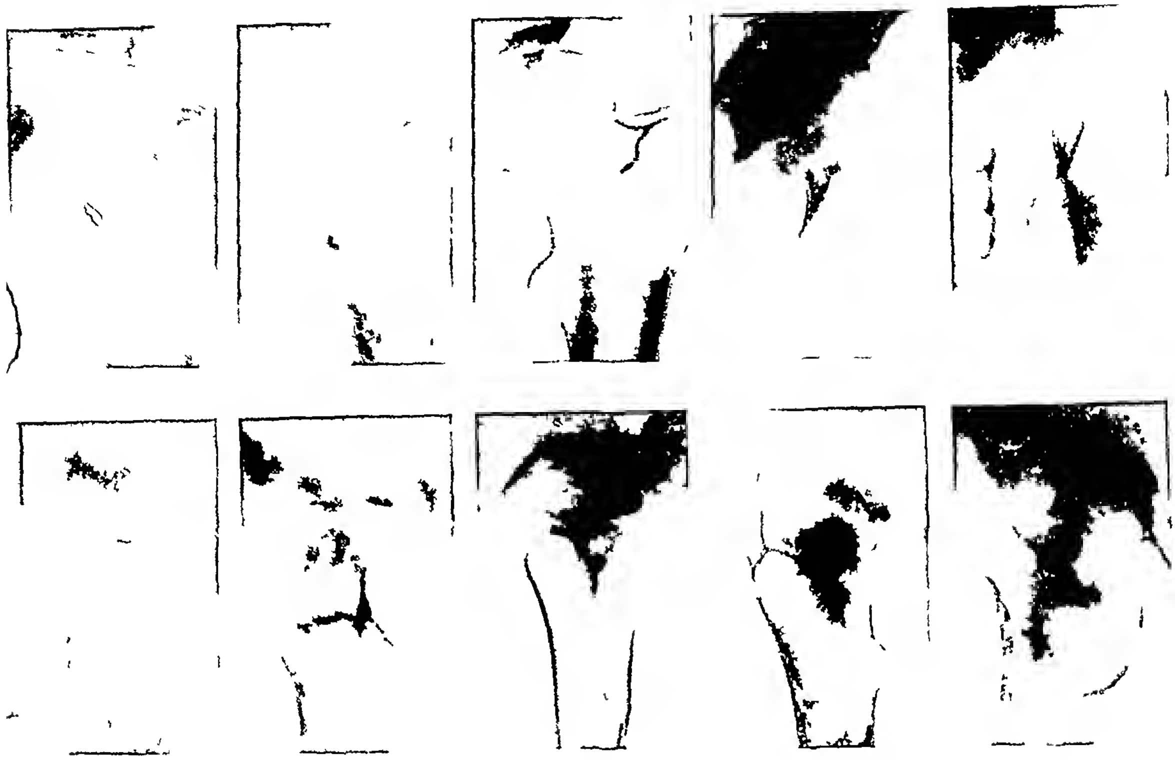

FIG 1

Radiographs of a series of fractures of the femoral neck (the upper row frontal plane the lower row lateral plane) the first two representing abduction fractures ' the third an ' intermediary fracture ' and the last two adduction fractures In fact, each represents an increasing degree of displacement arising from the same type of injury

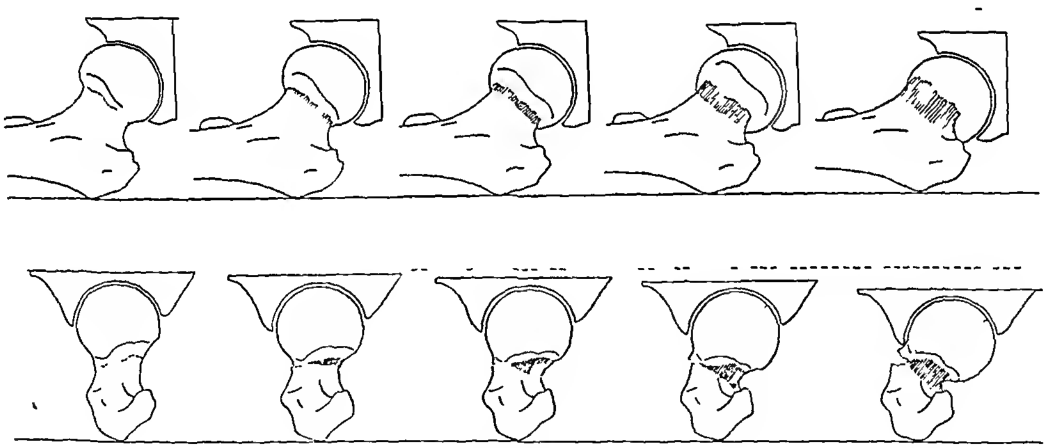

FIG 2

Progressive displacement of the fragments during the dislocating movement

Type of injury causing fracture of the femoral neck—It is often believed that differences in the position of the bone fragments as disclosed by radiography are due to different forms of injury But other factors than the direction of force may play a part—namely the degree of violence and the degree of resistance of the skeleton It is quite conceivable that valgus or varus relationships of the fragments may be attributable much more to the violence of injury, and the degree of resistance of the skeleton, than to the direction of the force of injury

It is recognised that a direct blow to the hip joint may cause any of the fractures that have been described, and that after such injury the frequency of the various types of

displacement is the same as in the whole series In other words, the type of displacement does *not depend necessarily on* the direction or type of violence

Moreover it is difficult to believe that serious displacement of the fragments should depend essentially on the application of lateral rotation strain When a patient falls on his hip joint, it is more than likely that the limb will be flexed at the knee joint so that rotation strains may not be transmitted to the hip Nor, in such circumstances, does the position of the pelvis undergo any noteworthy change by which the trunk would be rotated more constantly in one direction than another The explanation should be sought in the capacity of the femoral head to move in the acetabulum in response to compression by the posterior corticalis of the femoral neck It seems probable that the pelvis and shaft of the femur maintain their mutual relationship, and that displacement of the fragments arises solely by reason of rotation of the ball-shaped central fragment of the femur The fact that the limb lies in lateral rotation when the patient is admitted to hospital is a secondary consequence, and it does not follow that such displacement indicates the type or direction

FIG 3

FIG 4

A fracture of the femoral neck appeared to be a simple "abduction" fracture with impaction (Fig 3) It was treated without fixation in recumbency and while under *observation displacement developed It became a typical "adduction" fracture* (Fig 4)

of the initial violence The terms abduction and adduction fracture, or the equivalent terms valgus or varus fracture, cannot be regarded as suitable

Changes in the type of displacement of femoral neck fractures—Certain abduction fractures, while under observation, have changed in their position and thereafter shown the typical displacement of adduction fractures (Figs 3 and 4) It is thus evident that one type of fracture may pass readily into the other Moreover, adduction fractures, at the time of reposition, pass through all the stages shown in Fig 1 though in the reverse direction Some patients have been admitted to hospital with a history of being able to move the limb actively, and even to walk for several days after injury, who suddenly complained of increased pain and loss of ability to walk On admission there has been evidence of a fracture of the adduction type which would not permit easy walking or active movement It must be assumed that these were cases of abduction or "intermediary" fractures in which displacement increased and thereafter became of the adduction type

Study of a specimen of intermediary fracture of the femoral neck—The post-mortem specimen of an intermediary fracture in which there was good contact between the femoral head and neck shows that two fragments were broken from the corticalis without being displaced (Fig 5) Study of this specimen leaves little doubt that the violence must have ceased at that moment, and that incipient displacement of the fragments was never completed Such breaking of the posterior corticalis of the femoral neck may, conceivably, take place in many cases but pronounced displacement occurs only when splintering and comminution is still more complete Perhaps this splintered part, which often takes the shape of an inlet in the posterior region of the neck, might be described as a passage delved by the head in the course of displacement of the fragments

Mean age of patients with abduction, intermediary, and adduction fractures of the femoral neck—The mean age of patients who sustain abduction and intermediary fractures is lower than that of patients who sustain adduction fractures The difference is fairly marked, and it is statistically significant This must be interpreted in terms of the greater power of skeletal resistance at younger ages so that at these ages the degree of displacement is arrested at an earlier stage

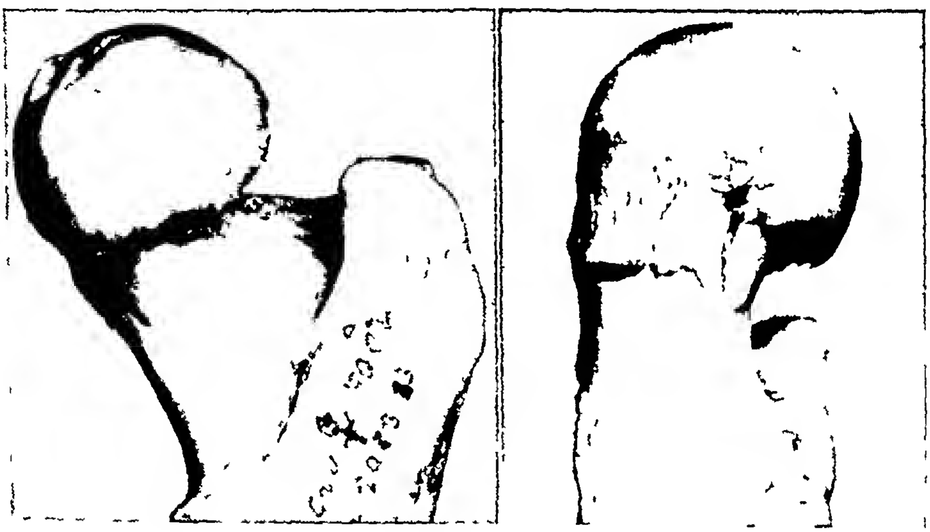

FIG 5

Post-mortem specimen of intermediary fracture of the femoral neck By radiographic examination this might have been classified as an abduction type of fracture but there is no impaction and it is clear that this represents no more than one stage of movement terminating in the characteristic displacement of an adduction fracture

Relative stability of abduction and intermediary fractures of the femoral neck—In abduction fractures the position is usually stable, and the degree of displacement does not increase after the initial injury has been sustained On the other hand, intermediary fractures are less stable, and this is in accord with the thesis that is being put forward In intermediary fractures the degree of injury is greater than in abduction fractures, and it is not surprising that displacement should often increase until the typical appearance of an adduction fracture is reproduced Intermediary fractures are therefore seldom seen, they accounted for no more than 8 6 per cent of this series of 323 fractures of the femoral neck

Summary—In summing up it may be said that various displacements in fractures of the femoral neck are in fact due to the same injury, and that different types of fracture are due to different degrees of displacement The displacing movement begins with the femoral head in slight abduction or valgus, and it ends when the head is on the posterior aspect of the femoral neck in adduction or varus, the displacements are the consequence of a single rotatory movement of the head

THE TRUE SIGNIFICANCE OF SO-CALLED IMPACTION OF FRACTURES

Returning to Figure 1 we see that a series of fractures of the femoral neck with increasing displacement appears to show impaction in the first three cases and failure of impaction in the last two The question that arises is why the first three types of fracture should ever have been considered to be "impacted" There is, of course, overlap of shadows in the radiographs—the appearance described by Nicole (1939) as *Konturuberschneidung* It is often assumed that such radiographic appearances indicate impaction, with hitching of the corticalis into the spongiosa at one or several places But this is probably untrue In general, such an appearance indicates no more than close contact between the fragments with limited breaking of bone tissue in one region, so that there is exact correspondence between displacement and compression These three factors—displacement, compression, and contact, are intimately connected, but the primary factor is displacement

FIG 6

FIG 7

FIG 8

Radiographic examination of the same case as in Fig 5 would suggest that this is an impacted abduction fracture of the femoral neck (Fig 6) An X-ray of the post-mortem specimen in one projection appears to support this (Fig 7), but in another projection it is obvious that there is no impaction (Fig 8)

There is much to be said in favour of the assumption that impaction, in the sense of interlocking of the fragments, does not exist A valgus fracture of the femoral neck with so-called impaction may be displaced by the simple process of inserting a three-flanged nail In the specimen shown in Figure 5 there is obviously no real impaction despite the radiographic appearances that suggest it This is confirmed in the illustrations of the same case, Figures 6 to 8 It is often assumed, because a patient can move his limb actively without pain, or even walk on it, that there is impaction, but this is to jump *to a conclusion—and it may well be that* the explanation lies in the fact that displacement is not yet sufficient to cause loss of stability

The assumption that there is impaction depends usually on close contact between the fragments, moderate compression of bone tissue, and reasonable stability in response to physiological demands—all these depending on the fact that the degree of displacement was limited by the resistance of the bone in relation to the degree of injury The so-called "impacted fracture" differs from no other fracture, it is sustained in the usual manner—but there is some degree of stability because displacement is limited and there is compression of bone tissue with contact between the fragments In short, an impacted fracture is no more than the first stage in a movement which, if it continues, will give rise to a more displaced fracture

So-called "impaction" may also be observed in fractures at the upper end of the humerus, lower end of the radius, upper and lower ends of the tibia, and in the vertebral bodies Limitation of displacement in fractures near the ends of long bones is often due to mobility of the adjacent joint—there is no long lever and, within certain limits, the articular fragment can follow movements of the longer fragment Since displacement is limited, the characteristics attributed to "impaction" are reproduced

Such fractures have in common the possibility of treatment with minimal external fixation, or even with early mobilisation and weight-bearing But it should be borne in mind that an "impacted" stable fracture with but little displacement, after perhaps an unnecessary reposition, can develop into a labile fracture which presents great difficulty in maintenance of reduction (Linton 1940)

SUMMARY

1 Various types of fracture of the femoral neck represent different stages of one and the same displacing movement

2 The displacement first produces an "abduction fracture" and terminates in an "adduction fracture," passing through the stage of an "intermediary fracture" which is less well recognised

3 These three types of fracture occur in response to the same injury and they differ only in the degree of displacement

4 It is a mistake to believe that in "adduction fractures" the femoral head lies medially to the collum it lies posteriorly

5 "Impaction" is no more than the first stage of displaçement of fractures in which there is limited displacement, with contact still maintained between the fragments

6 An "impacted fracture" is not necessarily stable—if there is additional strain it may progress to the next stage of a displaced and unstable fracture

7 These principles apply not only to fractures of the femoral neck but to all other fractures at the ends of long bones

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THE TREATMENT OF TROCHANTERIC FRACTURES OF THE FEMUR

E MERVYN EVANS, BIRMINGHAM, ENGLAND

From the Birmingham Accident Hospital *

The study of trochanteric fractures of the femur has received less attention in this country than elsewhere Conservative treatment has generally been accepted as the only rational treatment and, since the age groups are high, a mortality rate in the neighbourhood of one in five has been regarded as almost inevitable It is true of course that, if the patient survives, trochanteric fractures do well non-union is hardly mentioned in the literature, avascular necrosis never occurs, and the only complication to be expected with any frequency is coxa vara deformity But the problem is not primarily one of union of a fracture, or of function after union, it is one of preservation of life and general health in aged people whose fracture is but an incident in their general decline, and of combining humane and efficient care with conservation of hospital accommodation

In order to compare the merits of conservative and operative treatment we must study the results not only in patients that are treated in hospital but also in those that are sent home because there is a shortage of hospital beds If it can be shown that home treatment is unsatisfactory, either as regards the general comfort of the patient or the expectation of life, then any treatment that lessens the average length of stay in hospital, and thus increases the number of beds available, must be considered seriously For these reasons three groups of cases have been studied, namely one hundred and one cases treated conservatively in hospital, twenty-two cases treated by operative fixation of the fracture with a nail-plate, and twenty-five cases sent home because of shortage of hospital beds

TYPES OF TROCHANTERIC FRACTURE

Classifications of trochanteric fractures in standard text-books are based upon the level of the fracture—basal, pertrochanteric, transtrochanteric, and intertrochanteric—descriptions that have never been clear and are of no practical value Trochanteric fractures vary from the simple to the highly complex Some give rise to little or no difficulty, some can be coaxed into good position with reasonable certainty that the position will remain good, while in others deformity is inevitable A classification that laid emphasis chiefly on the stability or instability of the fracture would be of value both in considering prognosis and in deciding the degree of mobility of the patient that is permissible Such a classification, illustrated in Figure 1, is based upon study of the radiographs of one hundred and one fractures treated conservatively at the Birmingham Accident Hospital between the years 1941 and 1948 It became clear that the only deformity to be expected with any frequency was coxa vara, and that this occurred in approximately 20 per cent of cases

It is true of fractures in general that, when there is cortical instability on one side, the fracture tends to collapse in that direction no matter whether the instability is due to cortical overlap or cortical destruction Colles' fracture with destruction of cortical bone on the dorsal surface of the radius is a good example In the neck of the femur the bone is stronger along the calcar femorale where the greatest strain is thrown by the forces of gravity and muscle action, which tend to diminish the angle of the neck on the shaft After a fracture in this neighbourhood, cortical bone around the calcar femorale may remain in apposition with adequate immobilisation the fracture will not then collapse But when the cortical bone is overlapping, or when it is comminuted in such a way as to form a gap on the inner side, there is no resistance to collapse and coxa vara deformity is to be expected This

* *Read at the Annual Meeting of the British Orthopaedic Association in Belfast October 1948*

borne out in practice In the series now under review, coxa vara developed *only* in cases with cortical overlap or cortical destruction in the region of the calcar femorale, and furthermore, when cortical overlap was corrected during reduction the fracture became stable

In the suggested classification, trochanteric fractures are divided into two main types depending upon the general direction of the fracture Type 1 fractures are those in which the fracture line runs upwards and outwards from the region of the lesser trochanter, and there are four subdivisions In the first group, comprising 65 per cent of all cases, the inner cortical buttress has never been disturbed, there is no displacement, and the fracture unites

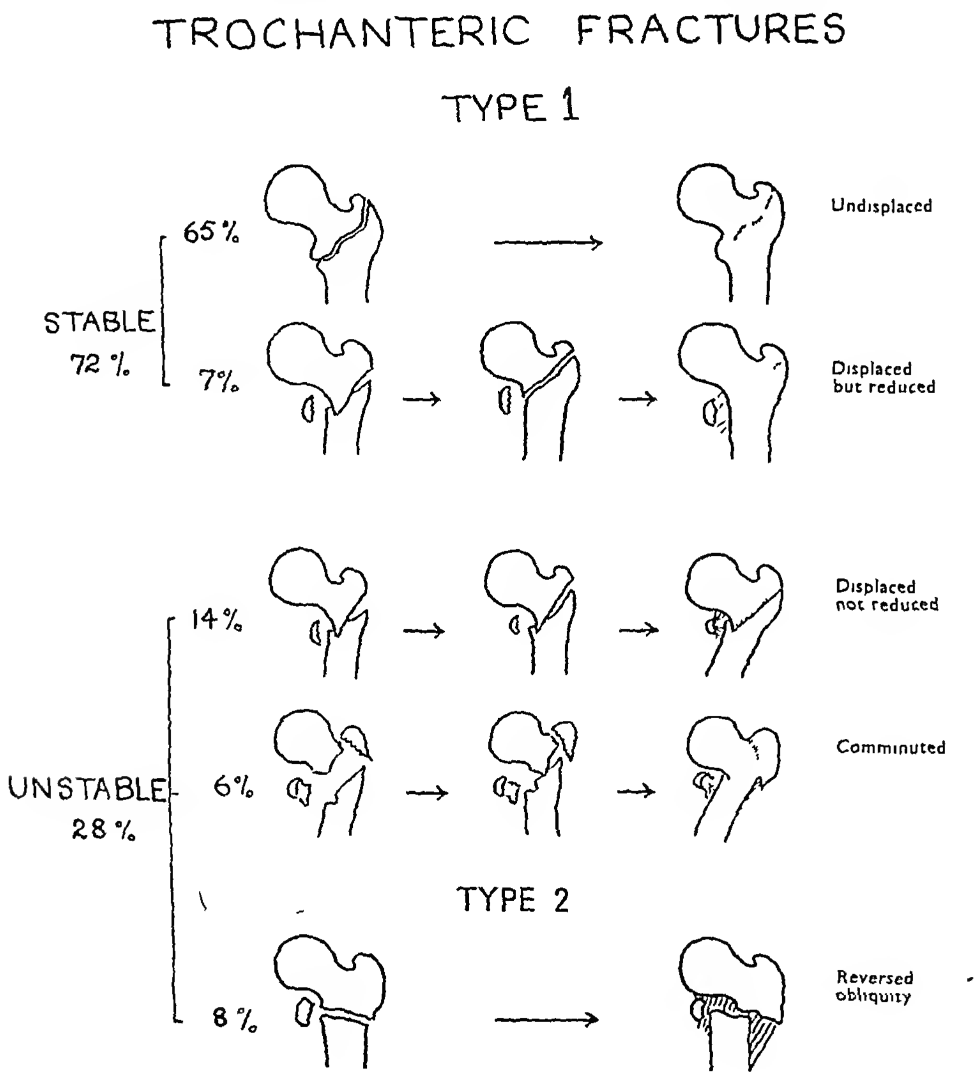

FIG 1

Classification of the two types of trochanteric fractures into stable and unstable groups

in perfect position In the second group, simple overlap of the inner cortical buttress can be reduced by manipulation and the fracture thus becomes stable In the third and fourth groups there is unreduced overlap, or destruction, of this cortical buttress and coxa vara deformity is to be expected

Type 2 fractures, occurring only in 8 per cent of the patients in this series, are those in which the line of fracture is the reverse of that usually found, corresponding roughly with the line of a McMurray osteotomy There is a marked tendency to inward displacement of the femoral shaft but this does not affect the ultimate function Figures 2 to 9 illustrate Type 1 and 2 fractures and their subgroups

Fig 2

Fig 3

Trochanteric fracture Type 1 group 1 (Fig 2) The inner cortical buttress is intact and there is no displacement The fracture is stable and will not displace (Fig 3)

Fig 4

Fig 5

Trochanteric fracture, Type 1, group 2 (Fig 4) Overlap of the inner cortical buttress has been reduced so that the fracture became stable and united without displacement (Fig 5)

Stable Varieties of Type 1 Trochanteric Fracture

FIG 6

Trochanteric fracture, Type 1, group 3 Overlap of the inner cortical buttress was never completely reduced The fracture was unstable and united with coxa vara deformity

FIG 7

Trochanteric fracture, Type 1, group 4 The inner cortical buttress was destroyed by comminution and the unstable fracture united with coxa vara deformity

Unstable Varieties of Type 1 Trochanteric Fracture

FIG 8

FIG 9

Trochanteric fracture Type 2 The main fracture line runs upwards and inwards through the femoral shaft in the same plane as that of a McMurray osteotomy

Type 2 Trochanteric Fracture

COMPARISON OF THE METHODS OF TREATMENT OF TROCHANTERIC FRACTURES

Conservative treatment in hospital—Table I summarises the results in 101 patients with trochanteric fractures treated conservatively in hospital In most of them, the method of treatment was balanced traction in a Thomas' splint, weight being applied to a Kirschner wire through the upper end of the tibia In sixteen cases a walking caliper was then used in an attempt to limit coxa vara deformity—an attempt that was usually unsuccessful The average age was 62 2 years (youngest 14 years, oldest 91 years) Fifteen patients died directly or indirectly from their accident

TABLE I

SUMMARY OF 101 TROCHANTERIC FRACTURES TREATED CONSERVATIVELY IN THE BIRMINGHAM ACCIDENT HOSPITAL 1941–48

Method of treatment—	
Traction in Thomas splint	81
Traction followed by caliper	16
Plaster spica	2
Bed rest	2
Average age	62 2 years (14–91 years)
Deaths	15=15 per cent
Length of stay in hospital (survivors)	15 weeks (6–36)
Residual deformity (survivors)—	
Coxa vara	18=21 per cent
Medial displacement of femoral shaft	7 per cent
Upward and backward displacement of femoral shaft	2 per cent

The mortality rate of 15 per cent compares favourably with that of other series of cases reported in the literature, but in one respect this series is not strictly unselected It is true that we have always admitted every patient with a trochanteric fracture if there was an empty bed, but when there was no empty bed there have been occasions when one was made available by hurriedly discharging someone else if the patient with a trochanteric fracture was a relatively good "surgical risk," but not if the patient was very old and feeble That this was so is shown by the age incidence of patients referred home for treatment because of shortage of hospital beds during part of the same period (1945–47) There were twenty-five such patients with an average age of seventy-seven years and a mortality rate of 44 per cent

Two other figures in Table I are of interest—the average length of stay in hospital of fifteen weeks, and the incidence of coxa vara deformity of 21 per cent Other deformities were infrequent, though it should be noted that inward displacement of the femoral shaft occurred in seven of the eight Type 2 fractures

TABLE II

SUMMARY OF TWENTY-TWO UNSELECTED TROCHANTERIC FRACTURES TREATED BY FIXATION WITH CAPENER-NEUFELD NAIL-PLATE

Average age	66 7 years (32–90 years)
Deaths	Nil
Average length of stay in bed (two cases excluded)	4 2 weeks (2 days–12 weeks)
Average length of stay in hospital (three cases excluded)	7 weeks (3–16 weeks)
Union in good position	18
Union with coxa vara deformity	4

Operative treatment in hospital—Table II is the summary of a series of twenty-two cases treated by fixation with Capener-Neufeld nail-plates This series is strictly unselected Three of the patients were operated upon in 1945 but the others form a continuous series of more recent origin during which time no patients were referred home for treatment nor were any denied operation because of poor general condition In some, the general condition was

very poor indeed but we believe that the risks of operating are less than the risks of conservative treatment This may seem unreasonable, but it should be remembered that the very old patients who usually sustain this injury tolerate pain and immobility badly, their mental state is often precarious, and they are quick to develop bedsores or pulmonary complications We believe that they should be treated as surgical emergencies and that the older and the more feeble the patient the more urgent is the need for operation One case history is quoted as an example

A T, **aged 80 years**—Admitted on September 29, 1948, having fallen on his right hip the night before He had sustained a severely comminuted Type 1 fracture and there was extensive bruising around the hip His general condition was excellent and he was taken to the theatre the same afternoon with the intention of inserting a nail-plate It proved difficult to secure good reduction and in view of the satisfactory general condition it was decided to treat the fracture conservatively by traction Forty-eight hours later there was serious deterioration in his condition, he was irrational and he spent most of the first night trying to insert both his legs into one Thomas splint Bruising around the hip had become very marked indeed and basal pneumonia had developed In the opinion of the anaesthetist his condition was desperate and with continued traction he was not expected to survive the week-end The only hope seemed to be to relieve his discomfort and make him more mobile by internal fixation The fracture was nailed on October 1, 1948 From that moment he began to improve and by the sixth day was afebrile rational and sitting up for several hours in a chair He was discharged home on October 26, 1948

All patients in the reported series were operated upon more than three months ago The average age was 66 7 years (32 to 90 years) There were no deaths Since the series closed, forty-three more patients have been treated in this manner (with four deaths) but sufficient time has not yet elapsed to include them, the overall average age has risen to 75 years All fractures in the series united—eighteen in good position and four with coxa vara It will be noted that this incidence of coxa vara deformity corresponds roughly with that occurring after conservative treatment The point is important because it should not be thought that internal fixation without external protection will always prevent deformity The strong forces inherent in the muscles around the hip joint are even greater than the strength of the nail, as there are many cases to show (Fig 13) In this, as in certain other fractures, it is even doubtful whether it is desirable to make any attempt to prevent the bones collapsing if the nature of the fracture is such as to demand it

It has been our practice to get patients out of bed as soon as possible after operation and, with experience, the length of stay in bed has become shorter, so that we now have them up in a chair within two or three days and usually teach them to walk on crutches within fourteen days The average figure of 4 2 weeks in bed is high because, at first, all patients were kept in bed for several weeks and these early cases raised the average Moreover, three patients were treated in traction after operation, two because they had combined trochanteric and subtrochanteric shaft fractures and the third because of insecure nailing The two cases excluded from this average had been bedridden for two years before the accident and naturally remained so The average length of stay in hospital was influenced by the same factors In present practice the length of stay in an uncomplicated case is in the neighbourhood of four weeks

INDICATIONS FOR OPERATIVE TREATMENT

From consideration of the results of conservative and operative treatment it seems clear that a case can be made for operative fixation of these fractures as a routine treatment If any exception is to be made it is not in the older age groups, for in these patients operation is a life-saving measure, it is in younger patients that something may be said for continuous traction, particularly if there is a contra-indication to operation Patients under the age of sixty years tolerate prolonged immobilisation well, but even in the young, the comfort and mobility of the patient, and the economic factor of length of stay in hospital, should usually outweigh reluctance to operate on a closed fracture Our reasons for advocating open fixation as a routine in trochanteric fractures may thus be summarised 1) greater comfort and increased mobility, 2) economy of beds, 3) lowered mortality

Fig 10

Fig 11

Lateral radiographs both before and after nailing show that there is cortical overlap on the inner side of the calcar femorale (inset Fig 10) The angulation at the fracture site is now recognised as due to *internal* rotation deformity The fracture united with coxa vara deformity the nail having cut upwards in the bone (Fig 11)

Fig 12

Fig 13

In the antero-posterior radiograph this appears to be an example of perfect nailing (Fig 12) There was good reduction and the nail was placed low with good penetration, no weight-bearing was permitted But the lateral view shows cortical overlap (inset Fig 12) and the fracture united with coxa vara, the nail having broken (Fig 13)

A case history illustrates the way in which open fixation stabilises the fracture and allows comparative freedom in dealing with the complications that must be expected from time to time in old patients

E C, **aged 83 years**—Admitted on August 20, 1948 having sustained a trochanteric fracture of the right femur the previous day The fracture was treated by open fixation with a Capener-Neufeld nail-plate on the day of admission The next day she was very comfortable, moving about freely in bed She sat out of bed for an hour on the second day On the third day she complained of abdominal pain, during the next forty-eight hours her condition deteriorated The abdomen became distended, bowel sounds disappeared and the pulse rate rose There was tenderness in the left iliac fossa Inquiry from relatives elicited a history of similar attacks over a number of years A diagnosis was made of large gut obstruction probably due to diverticulitis Transverse colostomy was performed on August 31, 1948 Pus was found in the peritoneal cavity She improved during the next few days, but later developed signs of a pelvic abscess which was drained per rectum After this she improved steadily She was allowed up again on September 21, 1948, and was discharged home on October 4, 1948, none the worse for her adventures except for the annoyance of a colostomy She was able to get in and out of bed herself and spent much of the day sitting in a chair She was a frail old lady and no attempt was made to get her up on crutches, but the fracture united in perfect position and she regained a full range of hip and knee movement

MORTALITY

No matter how trochanteric fractures are treated a certain mortality is to be expected In a patient over the age of eighty years such an injury throws a great strain on resources that are already failing "Some wounds are mortal" and the older the patient the more heavily are the scales weighted against her Nevertheless, in the series here reported, in which the fracture was treated conservatively, deaths occurred for the most part some weeks after injury and were due to the comparative immobility that is essential to continuous traction Bedsores, chest complications and mental deterioration were usually the deciding factors Operative treatment does away with this immobility in theory one would expect a lowered mortality, and this is borne out in practice

TABLE III

TROCHANTERIC FRACTURES—A Summary of Mortality Rates reported in the Literature

Author	Number of cases	Average age	Mortality per cent	
			Conservative	Operative
Leydig and Brookes	302		39 3	
Taylor *et al* 1940	108		20 3	
Wilson	62		24 3	
Key	214	66	38	
Bartels	40	70	25	
Siler and Caldwell	103		30 1	
Cleveland *et al*	38	78	34	
	95	75		12 6
Norton	49		39	
	51			25
Harmon	164		39	
	45			11 1
Taylor *et al* 1944	114		25 4	
	102			21 6
O Brien *et al*	103	70 6		21 4
Morris	28	77		21 4
Aronsson	30			10
Mean mortality rate per cent	1194—403 deaths		33 7	
	454—83 deaths			18 3

Table III is a summary of the mortality figures in apparently comparable series of cases reported in the literature There can be no doubt as to the difference—1,194 cases treated conservatively with 403 deaths, 454 cases treated operatively with 83 deaths—that is to say the average mortality from conservative treatment was 33 7 per cent as opposed to the average mortality from operative treatment of 18 3 per cent

FIG 14

FIG 15

Occasionally a good position may be maintained by a nail-plate despite cortical overlap (Fig 14) But this cannot be relied upon It is interesting to note three years later, how perfect is the reconstruction of the calcar femorale

FIG 16

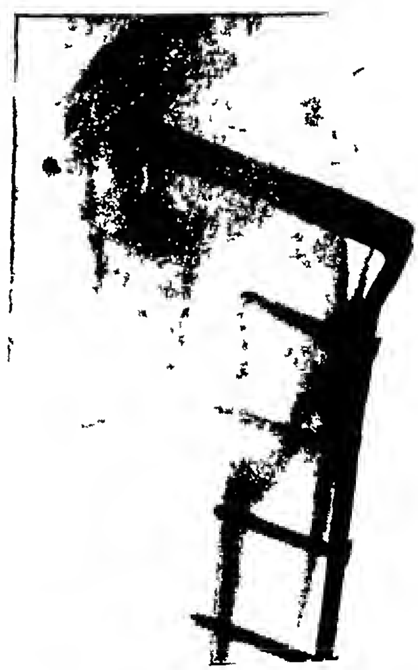

FIG 17

An unstable trochanteric fracture (Type 1, group 3) nailed in the position of deformity The radiograph shown in Fig 17 was taken immediately after operation There cannot be further collapse and no great strain will therefore be thrown upon the nail-plate

TABLE IV

COMPARISON OF THREE METHODS OF TREATMENT OF TROCHANTERIC FRACTURES

	Number of cases	Average age	Time in hospital	Mortality
No beds available—Discharged home	25	77	—	44 per cent
Conservative treatment—Birmingham Accident Hospital	101	62 2	15 weeks	15 per cent
Operative treatment—Capener-Neufeld nail-plate	22	66 5	7 weeks	Nil

Table IV summarises the results in the 148 cases under review The numbers in the first and third series are small, and the mortality figure of nil in the nail-plate series is, of course, fortuitous, but the general picture seems clear The mortality for cases treated at home is undoubtedly very high, and it is clear that the shorter the average length of stay in hospital the more patients we shall be able to treat, so that the two factors of mortality and length of stay in hospital are closely related In short, the operative treatment of this fracture may be expected to reduce the length of stay in hospital by half, and to lower the mortality - More important, perhaps, the old lady is more comfortable and more mobile after operation, and the incidence of stiffness of the knee and hip joints is markedly diminished

FIG 18

This photograph of a patient with a trochanteric fracture treated by operative internal fixation with a Capener-Neufeld nail-plate was taken within twenty-four hours of operation The patient is obviously comfortable and happy and there is a good range of movement of the hip and knee joints

OPERATIVE TREATMENT OF TROCHANTERIC FRACTURES

The operation is little more upsetting to the patient than the insertion of a Smith-Petersen nail and it should be completed within forty-five minutes After omnopon premedication we have used pentothal and gas and oxygen anaesthesia A blood transfusion of one to two pints is started just before the operation

The technique of the nailing procedure, and the prognosis as regards stability after nailing, depend upon the condition of the inner cortical buttress Overlap of cortical bone may be visible only in the lateral view but unless this can be reduced coxa vara deformity is to be expected Figures 10 and 11 illustrate a fracture that was nailed without correction of cortical overlap In the antero-posterior view the fracture appears stable but the lateral views, both before and after nailing, showed cortical overlap and the fracture united with coxa vara deformity—on this occasion by the nail cutting upwards in the femoral neck. In such a case if the nail cannot cut upwards it will usually bend Figure 12 shows a post-operative radiograph which in the antero-posterior view appears perfect—a low nail with good penetration and an apparently stable reduction The lateral view, however, shows cortical overlap Coxa vara developed, this time with bending, and later breaking, of the nail (Fig 13) Figures 14 and 15 show that a nail-plate can occasionally hold the comparatively unstable fracture in good position, but such a result is not to be relied upon If there is gross

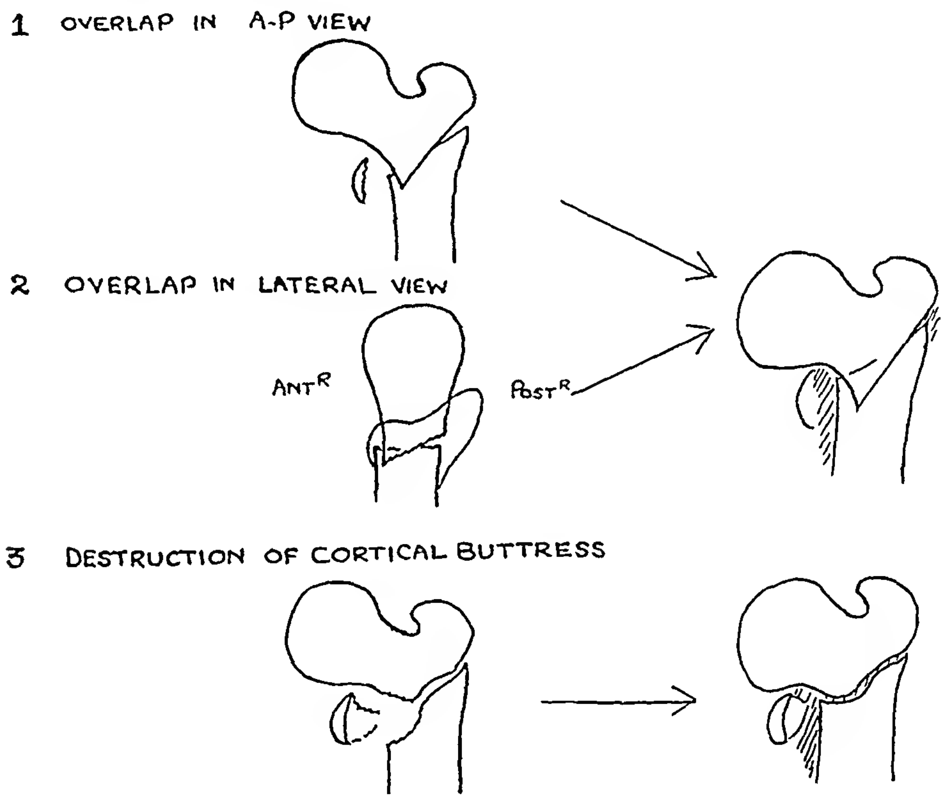

FIG 19

Trochanteric fractures of the femur Diagrams illustrating the importance of the medial cortical buttress in the development of coxa vara deformity

cortical insufficiency on the inner side the fracture will almost certainly collapse, and no force, whether applied internally or externally, will prevent it In order to avoid the possibility of a nail-plate cutting out or breaking before union has taken place we now aim, in comminuted and unstable displaced types of fracture, to fix the fragments in the position of deformity (Figs 16 and 17)

As was pointed out by Morris (1941), these fractures need to be held in the neutral or externally rotated position Internal rotation separates the fracture surfaces and angulates the fragments Occasionally the limb must be held in considerable external rotation in order to maintain good reduction in the lateral plane, this makes the operation awkward but it overcomes the technical difficulty of trying to insert a nail when there is angular deformity in the lateral plane Flexion during the reduction, and particularly extreme flexion as in the Leadbetter manoeuvre, is to be avoided If, after initial reduction, radiographs in the

FIG 20

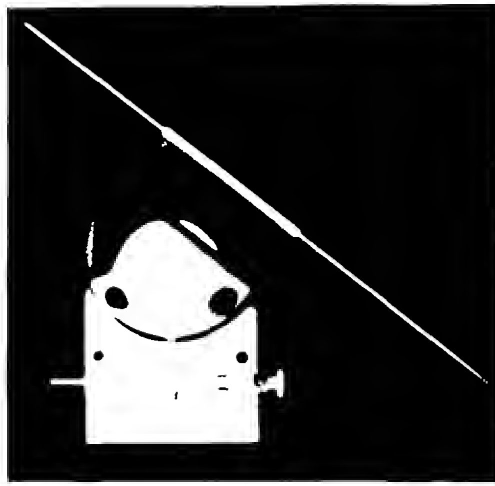

FIG 21

Director devised to assist the insertion of a nail into the femoral neck in such an axis that the plate will lie in accurate contact with the femoral shaft (Fig 20) A radiograph of the instrument shows the series of parallel guide-wire channels (Fig 21) the distance between each pair is exactly equal to that between the V of the nail and the topmost hole of the plate so that two wires can be introduced and the nail-plate be driven over them The angle can be adjusted to conform with the angle of the most suitable nail-plate There is a cross-pin at the base of the instrument which is inserted into a ⅛-inch drill-hole in the shaft of the femur in order to steady it

FIG 22

FIG 23

The director is in position and the first guide-wire has been driven in (Fig 22) After confirming the position in antero posterior and lateral radiographs the second wire is inserted and the nail-plate is then introduced (Fig 23) The plate automatically lies in accurate contact with the femoral shaft and four screws are then introduced engaging both cortices of the shaft

both planes show that the fracture is of the unstable type, the traction should be reduced and the shaft fragment be pushed inwards and upwards, and then be nailed in this position

We have used the Capener-Neufeld nail-plate because it is very strong, particularly at its angle, and it is obtainable in three angles and four lengths to suit all types of patient The only difficulty in its insertion is placing the nail in the neck of the femur in such a position that when it is hammered home the plate lies parallel with the shaft It is not easy to do this by eye alone and the author has therefore designed a director with a series of parallel guide-wire channels, the angle of which may be set to correspond with the angle of the nail-plate chosen (Figs 20–23) When satisfactory reduction of the fracture has been obtained, a estimate of the best of the three angles of nail is made by holding the nails against a radiograp of the reduced fracture and the director is then set accordingly The distance between each channel in the director is the same as that between the V of the nail-plate and the topmost

FIG 24

FIG 25

A stable trochanteric fracture (Fig 24) in which weight-bearing was encouraged a few days after internal fixation with a Capener-Neufeld nail-plate Union took place in perfect position (Fig 25)

hole, so that two guide wires may be inserted, accurately spaced, for the introduction of th nail The cross-pin at the base of the instrument fits into a ⅛-inch drill-hole in the latera femoral cortex and steadies it during the operation

In estimation of the length of nail it should be borne in mind that if there is gradu collapse and absorption of bone at the fracture site the nail-plate cannot be extruded, as ca a Smith-Petersen nail, but is forced nearer the hip-joint and may penetrate it The point o the nail should not therefore be nearer than one centimetre to the joint surface at the e of the operation The nail is eventually hammered home between two guide wires, one the V and the other in the topmost hole of the plate. The plate automatically lies again the femoral shaft and is fixed with four screws, each with a hold on both cortices The woun is closed and the patient is returned to the ward with a firm bandage around the hip other fixation is necessary

In stable group 1 fractures in which adequate internal fixation has been obtained the patient may bear weight on the affected limb from the beginning (Figs 24 and 25) When reduction is not perfect, and particularly when the inner cortical buttress is not restored, weight-bearing should not be allowed until the fracture has united Nevertheless the patient should be got up on crutches Non-weight-bearing exercises, general limb movements and breathing exercises are started immediately

SUMMARY

1 Trochanteric fractures are classified, with special emphasis on the stability or instability of the fracture The importance of the cortical buttress of bone on the inner side of the femoral neck and shaft is stressed

2 Three series of cases are presented *a*) one hundred and one cases treated conservatively in hospital, *b*) twenty-five cases sent home by reason of lack of hospital beds, *c*) twenty-two cases treated by fixation with a Capener-Neufeld nail-plate

3 From consideration of these three series, and from study of similar series of cases reported in the literature, it is suggested that routine operative treatment of trochanteric fractures has the advantages of greater comfort and mobility of the patient, lowered mortality, and economy of hospital beds

4 Certain features of the operation of internal fixation by the Capener-Neufeld nail-plate are discussed A director, for more efficient insertion of the nail-plate, is described

5 The importance of early mobility after operation is emphasized Only a small proportion of patients can be allowed early weight-bearing but almost all can be got up in a chair, and most can be taught to get about with crutches, without weight-bearing on the fractured limb, within a few days of operation

I am indebted to Mr William Gissane for help and encouragement in the preparation of this paper I would also express my thanks to Mr Farrar of the Austin Motor Company who made the new instrument described to Mr Gill of the Photographic Department for preparation of the illustrations and to my colleagues on the surgical staff of Birmingham Accident Hospital for allowing me to operate on their cases

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TROCHANTERIC FRACTURES OF THE FEMUR

A Plea for Conservative Treatment

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In recent years, operative methods have been advocated strongly in the treatment of fractures of the trochanteric region of the femur For these fractures, internal fixation appears to have become standard treatment in many clinics in the United States of America and an article in the 1946 Year Book of General Surgery is introduced with the observation that "internal fixation is still the method of choice for most intertrochanteric fractures" This treatment is also gaining popularity in Great Britain and we are informed that blade plates "are selling like hot cakes"

The difficulties of conservative treatment are appreciated and we are aware that the results have not always been good, but our impression does not conform at all with the opinion of many writers who advocate internal fixation Furthermore, in studying the literature we have read fallacious statements, faulty conclusions and unjustified claims, and some papers written in support of internal fixation have actually strengthened our belief in routine conservative treatment In order to test the validity of this belief, a series of cases treated conservatively during the past six years has been investigated The results appear to justify our plea for conservative treatment

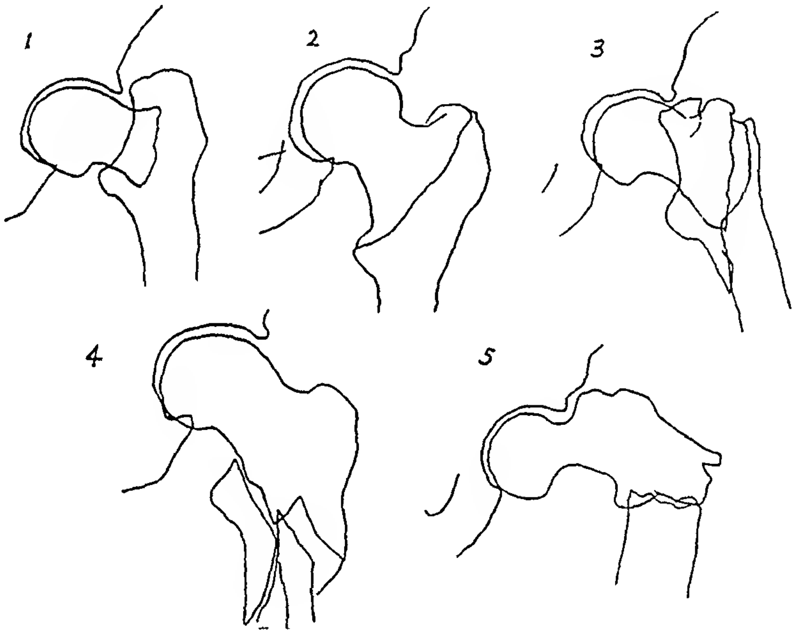

Fig 1

Tracings of radiographs illustrating the five types of intertrochanteric fracture of the femur 1) basal, 2) intertrochanteric 3) comminuted intertrochanteric 4) oblique subtrochanteric 5) transverse subtrochanteric

REVIEW OF CASES

The series of cases consists of one hundred consecutive trochanteric fractures of the femur—forty-six being treated at Killearn Hospital, Glasgow, between 1941 and 1943, and fifty-four at Raigmore Hospital, Inverness, between 1944 and 1947

Types of Fracture—The investigation includes not only intertrochanteric and pertrochanteric fractures, but also fractures through the base of the femoral neck and subtrochanteric fractures. Avulsion and crack fractures of the greater and lesser trochanters have been excluded. The fractures have been classified into five types, which are illustrated in Fig. 1 by radiographic tracings of typical examples. The term "basal" has been used to describe fractures through the base of the neck and not, as some authors use it, to cover all varieties of intertrochanteric and pertrochanteric fractures. It is probably more common than is generally recognised, and is often mistaken for an intertrochanteric fracture (Figs. 2 and 3). Classification has not always been easy because some fractures combine the features of two types. Thus, a fracture which is mainly across the base of the neck may pass obliquely through the intertrochanteric line, and a comminuted intertrochanteric fracture may be associated with a subtrochanteric fracture. The oblique subtrochanteric group is particularly varied and could easily be subdivided; some consist of a simple fracture passing upwards and inwards to just above the lesser trochanter, but most are comminuted, extending up to the intertrochanteric region, while others extend down into the shaft. In this series (Table I) the most common type was the comminuted intertrochanteric fracture (43 per cent.) and the least common was the transverse subtrochanteric fracture (2 per cent.).

TABLE I

DISTRIBUTION OF TYPES, SEX, AND AGE

Type of fracture	Number of cases	Male	Female	Age	
				Range	Average
1 Basal	12	5	7	17–81 years	59 years
2 Intertrochanteric	25	17	8	15–79 ,,	54 ,,
3 Comminuted intertrochanteric	43	22	21	16–90 ,,	69.8 ,,
4 Oblique subtrochanteric	18	11	7	20–92 ,,	61.2 ,,
5 Transverse subtrochanteric	2	1	1	47–66 ,,	56.5 ,,
Total	100	56	44	15–92 years	62.5 years

Age—It is often believed that trochanteric fractures are sustained only by elderly patients, but in this series there were many young patients, the ages ranging from 15 to 92 years. Details are given in Table I, which shows that the average age at which comminuted intertrochanteric fractures are sustained is 69.8 years, whereas the average age for simple intertrochanteric fractures is only 54 years. Analysis of the age incidence in each decade shows that although these fractures occur most frequently between the ages of 70 and 80 years, and 67 per cent. occur over the age of 60 years (average 74.7 years), 15 per cent. are sustained by patients of less than 40 years (average 25 years). More than one-third of simple intertrochanteric fractures were in patients of less than 50 years, but on the other hand nearly two-thirds of comminuted intertrochanteric fractures were in patients of more than 70 years.

Sex—Fifty-six patients were males and forty-four were females. This preponderance in males is in striking contrast with most other recorded series. Nearly always these fractures have been reported as occurring much more often in women than in men. Table I shows the sex distribution in the five types of fracture. The higher male incidence is especially noticeable in simple intertrochanteric fractures of which 68 per cent. occurred in men.

Associated diseases—Many patients suffered from other pathological conditions—diabetes, spastic hemiplegia, paralysis agitans, subacute combined degeneration, Paget's disease, rheumatoid arthritis, osteoarthritis, chronic osteomyelitis, arterio-sclerosis, and coronary disease The frequency of osteoarthritis of the hip joint in patients who sustain trochanteric fractures calls for emphasis because it has an important bearing on the end-results In a recent consecutive series of thirty-three cases it was found that the hip joint was normal in only one-third, in another third there was early osteoarthritis, and in nearly 20 per cent of cases there was advanced osteoarthritis

FIG 2

FIG 3

Radiographs of basal fracture before reduction illustrating the difficulty in identifying the type (Fig 2) and after reduction (Fig 3) showing that the fracture line is confined to the neck in this case more oblique than usual

TREATMENT OF TROCHANTERIC FRACTURES

With few exceptions, the fractures in this series were treated by traction Skeletal traction was employed in only six cases, traction by adhesive strapping was used in all others Our early practice was to place the limb on a Braun's splint unless external rotation deformity was marked, in which case a Thomas' or Hodgen's splint with an internal rotation bandage was used More recently, splints have been discarded altogether for all fractures except those at the subtrochanteric level, the limb being placed on a pillow with 12 to 18 lb traction over a pulley at the end of the bed, and an internal rotation bandage applied just above the knee slung by a light weight of 3 to 4 lb (Fig 4) A similar method of correcting external rotation deformity was recently described by Rose (1947) Before this method was employed it was found necessary to manipulate eleven cases under anaesthesia in order to correct deformity, but since its introduction no manipulation has been required in twenty-five cases, though twenty of them had severely comminuted fractures with marked deformity It is now our policy to use manipulation only if full correction is not secured within a week, but it is remarkable how quickly and easily complete reduction is usually obtained (Figs 9 and 18) The method is no less applicable to intracapsular fractures before pinning and we now use it routinely Counter-traction is provided by raising the foot of the bed on low blocks The patient is placed in a semi-sitting position, supported by pillows or a back-rest From the first day of treatment he is encouraged to move about in bed, sit up freely, and assist the nurses by lifting himself with the aid of a handle suspended from the Balkan beam Most patients, even the aged, if they are taught to bend the good knee to a right angle and place

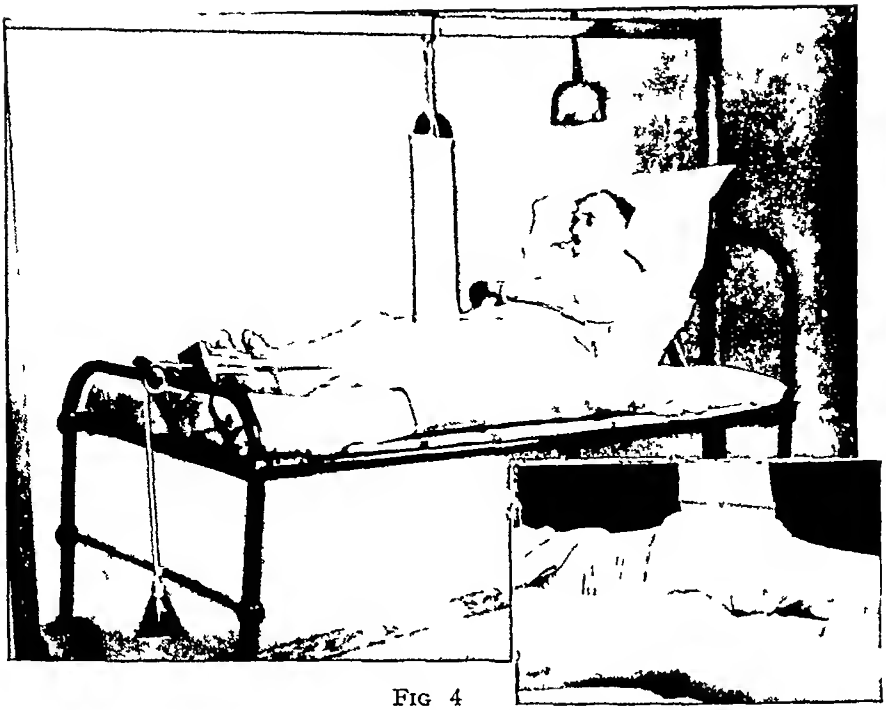

FIG 4

Patient aged seventy-four years, with comminuted intertrochanteric fracture, illustrating method of treatment by simple traction and suspended internal rotation bandage Inset shows the manner of applying the rotation bandage

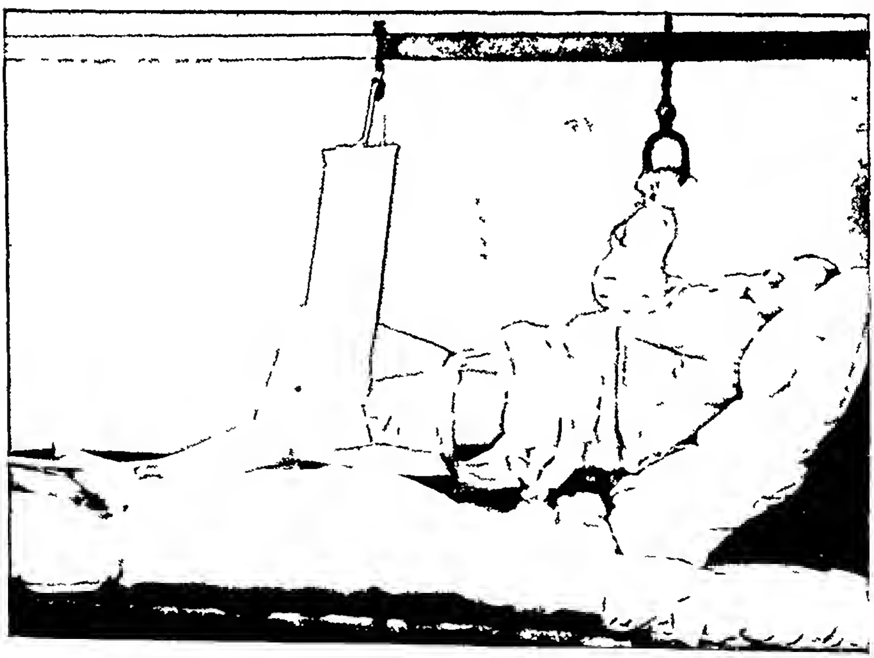

FIG 5

Same patient as in Fig 4 lifting herself for nursing purposes

the foot flat on the bed, soon learn to raise themselves and lift their buttocks for washing and the use of bed-pans (Fig 5) The physiotherapist supervises exercises for the foot, quadriceps drill, and active movements of the sound limb at regular intervals At first, movement of the knee joint of the fractured limb was not encouraged until the eighth week, but gradually this time has been shortened until during the past year most patients started knee exercises between the third and fifth weeks Some patients with undisplaced intertrochanteric fractures can start knee movement as early as the first or second week after injury After about three weeks the hip can usually be flexed passively without pain, thus permitting some flexion of the knee After the fourth week, provided that no splint is used, it is a simple matter for the physiotherapist to remove the traction weight, maintain slight traction by hand, and assist the patient to put his leg obliquely over the side of the bed and in this position exercise the knee In grossly comminuted fractures, and most subtrochanteric fractures, movement of the knee joint is more delayed Subtrochanteric fractures are usually treated in a Thomas' splint with Pearson flexion piece, and it is usually five to seven weeks before knee movements are permitted

TABLE II

AVERAGE TIME IN WEEKS FOR DIFFERENT STAGES OF TREATMENT

	Basal	Intertro-chanteric	Comminuted intertro-chanteric	Oblique subtro-chanteric	Transverse subtro-chanteric	All types
Time on traction	9 5	8 3	9 4	10 5	11	9 5
Time before starting exercises	6 5	4 6	6 2	7 3	5	6 1
Time in bed	12	9 5	11 3	13	11	11 1
Time in hospital	15 7	11 6	14 8	16 2	12	14 3

Radiographs are taken at intervals throughout treatment When clinical and radiographic evidence shows that union has progressed sufficiently, traction is discarded gradually —that is to say the weights are first reduced in stages, and are then removed for increasing periods, until finally they are discarded altogether This transition period usually extends from the ninth to the twelfth week of treatment In most cases walking with crutches is permitted after twelve weeks, but full weight-bearing is not permitted until radiographs show consolidation of the fracture When the fracture extends downwards to involve the shaft of the femur a caliper splint is worn until there is consolidation, usually from four to six months from the date of injury

Table II shows the average time in weeks for different stages in the treatment of the five types of fracture and for the series of one hundred cases as a whole Perhaps the most striking feature is the difference in time at comparable stages between basal and simple intertrochanteric fractures It should be noted that during the past two years exercises have been started much earlier than formerly Thus, for the last twelve intertrochanteric fractures the period of delay has been reduced to 3 5 weeks, and for the last twelve comminuted intertrochanteric fractures to 4 8 weeks

RESULTS OF TREATMENT

When assessing the results of treatment of injuries of this nature there are so many factors to consider that it is not easy to present a true picture in tabular form For purposes of analysis, and comparison with other series, it is necessary to consider both anatomical and functional results, and these have been summarised in Table III They have been

FIG 6

Comminuted intertrochanteric fracture in a hemiplegic patient four weeks after injury Very marked varus deformity persisted despite heavy traction due to spasticity of the adductor muscles

FIG 7

FIG 8

Comminuted intertrochanteric fracture (type 3) associated with moderate osteoarthritis of the hip joint (Fig 7) After seven months it is seen that the fracture is consolidated in almost identical position (Fig 8) The poor functional result was due to pre-existing arthritis—not to the fracture.

classified into four grades *Anatomical*—1) Excellent—no shortening or deformity, clinically or radiographically, 2) Good—up to half an inch of shortening, but no rotation or adduction deformity, 3) Fair—half to one inch of shortening, slight adduction deformity, or slight rotation deformity, 4) Bad—more than one inch of shortening, obvious adduction deformity, or rotation deformity *Functional*—1) Excellent—full range of hip movement, no disability, 2) Good—slight limitation of hip movement, other disability hardly appreciable, 3) Fair—considerable limitation of hip movement (up to 50 per cent), able to walk without crutches, but often requiring a stick 4) Bad—more than 50 per cent limitation of hip movement, ability to walk only with crutches or not at all

TABLE III

Type of fracture	Anatomical results				Functional results				Died
	Excellent	Good	Fair	Bad	Excellent	Good	Fair	Bad	
Basal	4	3	4	1	4	4	3	1	—
Intertrochanteric	17	5	1	1	11	9	2	2	1
Comminuted intertrochanteric	9	13	11	3	8	19	6	3	7
Oblique subtrochanteric	3	6	5	2	2	8	3	3	2
Transverse subtrochanteric	—	2	—	—	—	2	—	—	—
Total	33	29	21	7	25	42	14	9	10

This classification does not take into account the condition of the hip joint before injury A number of patients suffering from osteoarthritis of the hip were classified as having a fair or bad functional result, though probably the stiffness which led to this classification was present before the fracture was sustained (Fig 7), indeed several of these patients considered that they were fully restored to normal Similarly the bad results include patients with spastic paralysis who were almost totally disabled before the injury, the fracture itself having little or no effect on the degree of disability A study of Table III indicates that of the ninety survivors, sixty-two had good or excellent anatomical results and sixty-seven good or excellent functional results There were only seven bad anatomical results, and nine bad functional results It is worth inquiring further into the cases classified in grade 4 as bad results

Analysis of bad results—In thirteen cases the result was classified anatomically or functionally as bad, their average age was seventy years The average time spent in hospital was eighteen weeks Of these, nine were suffering from a serious pre-existing pathological condition There were four cases with severe osteoarthritis of hip joint, one also suffering from diabetic neuritis Four had an upper motor neuron lesion, three being almost bedridden One had rheumatoid arthritis Of the other four cases one was complicated by femoral thrombosis during treatment, one was the case of non-union to be referred to later, and one was treated in a plaster spica (which was exceptional and, we think, unfortunate) The other case was a straightforward comminuted intertrochanteric fracture in a patient aged eighty three years, who despite one and a half inches shortening has good function

Knee function—A special study has been made of the range of knee movement in patients treated in Inverness who have been observed for six to forty-eight months after injury In 62 per cent of these patients there was a full range of knee movement In 23 per cent there was more than 90 degrees of movement In 4 per cent the knee joint was very stiff In the other cases there was osteoarthritis or spastic paralysis, but the joint was restored to its original condition

Fig 9

Fig 10

Comminuted intertrochanteric fracture (type 3) in a woman aged seventy-two years sixteen days after application of traction and internal rotation bandage (Fig 9) note the early callus Fig 10 shows consolidation after five months with only a trace of shortening normal movement of the knee joint, and full restoration of normal function

Fig 11

Fig 12

Oblique subtrochanteric fracture (type 4) in a woman aged seventy-four years (Fig 11) Six weeks later union in almost perfect position was well advanced (Fig 12) The final result—anatomical and functional—was excellent

Complications—Drop foot, 9 cases (see Discussion), hypostatic pneumonia, 5 cases, all died, broncho-pneumonia, 3 cases, 2 died, bed sores, 3 cases, pulmonary embolism, 2 cases, both died, psychoses, 2 cases, femoral thrombosis, 1 case, cerebral haemorrhage, 1 case, died, non-union, 1 case

Mortality—In this series of one hundred consecutive cases there were ten deaths due to hypostatic pneumonia and congestive heart failure, 5, broncho-pneumonia, 2, pulmonary embolism, 2, cerebral haemorrhage, 1 The average age was eighty years

FIG 13

FIG 14

Transverse subtrochanteric fracture associated with Paget's disease (Fig 13) Union in good alignment is shown radiographically both in the antero-posterior projection (Fig 14) and the lateral projection (inset)

DISCUSSION

These results have been presented in order to illustrate an average experience of the conservative treatment of trochanteric fractures Broadly speaking, any condition that can be treated with equal success by operative or conservative methods should not be treated by operation For example, it would be inexcusable to operate routinely on fractures of the shaft of the humerus, whereas nailing of transcervical fractures of the neck of the femur is usually advisable owing to the high incidence of non-union after conservative treatment Protagonists of the operative treatment of trochanteric fractures have put forward many justifications for their methods They claim better anatomical and functional results, greater certainty of union, earlier ambulation with economy of hospital beds, easier nursing prevention of bed-sores, fewer complications, and above all, a lower mortality It is easy enough to be overwhelmed by so formidable a list of benefits, but it is worth looking into each of these claims more closely

Anatomical Result—It would be natural to expect more accurate reduction from a skilful operation than from traction alone, but the operation is not always easy and the requisite

skill is not always available Even the results that have been published are not all good, and it is to be expected that among unpublished records there might be many curious radiographs Taylor, Neufeld, and Janzen (1944) reported a series of 159 cases treated by internal fixation, and claimed excellent anatomical results, yet they went on to say that restoration of the angle of the neck averaged three degrees less than from closed traction because reduction at the time of nailing was inefficient

It might also be expected that reduction would be maintained more securely by internal fixation, but even this is by no means certain We have seen cases in which the plate became detached from the shaft owing to loosening of the screws, and this complication, as well as breaking and bending of nail-plates, has often been reported (O'Brien, Shy, and Bublis 1946, Siris and Ryan 1944) In a recent report of ninety-five cases treated by a modified Jewett nail-plate (Cleveland, Bosworth, and Thompson 1947) there were three cases of breaking of the nail, one of bending of the nail, and four of disruption of the plate

In our own series of cases treated conservatively (Table III), sixty-two of the ninety survivors (68 9 per cent) had good or excellent anatomical results Only seven results were bad, even when such pre-existing conditions as spastic hemiplegia were included With few exceptions, we have found little difficulty in securing union in good position There is very little difficulty in securing anatomical perfection in young patients who have no problems of senility or psychosis, and are willing and able to co-operate, internal fixation is certainly unnecessary in this age group But even in old patients, despite all their problems, we have had little difficulty in securing satisfactory results (Figs 9–14) In a few cases there has been shortening of the limb by one inch, and very occasionally by more than one inch, but a little shortening is of no concern to a patient of more than seventy years who has a painless, stable and mobile hip

Functional Result—It is claimed that functional results are better after internal fixation because exercises can be started sooner Stiffness of the knee joint is of course a real danger in old people, and experience with the nailing of transcervical fractures has shown that stiffness can usually be prevented if exercises are started early Nevertheless, in employing conservative treatment for trochanteric fractures, we have found that knee exercises can be started at an early stage without interfering with union We encourage knee movements as soon as they can be attempted without causing pain in the region of the fracture—within a very few weeks of injury

Range of knee movement—It is a remarkable fact that in all the records of internal fixation of trochanteric fractures we have been unable to find statistics of the range of knee movement, and we cannot but wonder whether some operators, in their enthusiasm for operations, have always paid attention to the function of the limb as a whole Our own figures show that after conservative treatment knee function is not often impaired Only in 4 per cent of patients was there serious stiffness in two-thirds, the final range of knee movement was normal

Early ambulation and the dangers of recumbency—In this series, the average period of recumbency was just over eleven weeks (Table II) With internal fixation most authors make it clear that weight-bearing should not be permitted until bone union is established, but they allow the patient up with crutches six to eight weeks after operation O'Brien, Shy, and Bublis (1946) encourage the patient to sit in a chair on the fifth day and to walk with crutches after six weeks Stuck (1944) considers that nothing is gained by early ambulation, and that there is danger of circulatory damage at the fracture site if the patient is allowed up before eight weeks Harmon (1945) does not permit walking with crutches before eight weeks, complicated cases may be kept recumbent for fourteen to sixteen weeks

Certainly internal fixation permits earlier disposal of patients than does conservative treatment which usually demands from ten to fifteen weeks in hospital But even in these days of nursing shortage we do not regard this as a factor which should weigh heavily

FIG 15

Severely comminuted fracture with impaction adduction of the shaft advanced osteoarthritis of the hip joint and abduction deformity at the hip joint

As was observed by Osmond-Clarke (1947 "It is a dangerous policy (though one tha is becoming too prevalent) to argue tha shortening of the stay in hospital, or th achievement of earlier ambulation, is i itself sufficient ground for advising opera tive treatment of fractures"

It appears to be assumed generally tha patients who are treated in recumbency ar in mortal danger If that was true, earl ambulation would be of primary import ance But we do not believe that it is true With few exceptions, old people tolerat recumbency remarkably well * We do no imply that the risk of recumbency shoul be disregarded, but we would assert tha careful nursing, attention to posture, and early active movement of the patient in bed, are far more important than early ambulation

Nursing and pressure sores—It is a sad reflection on the capability of orthopaedic nurses if the management of an average trochanteric fracture treated in traction is to be regarded as a serious problem Many authors refer to the frequency of severe pressure sores, especially on the sacrum and heels Cleveland, Bosworth, and Thompson (1947) go so far as to say that with conservative treatment pressure sores are the rule rather than the exception They seem to consider that it was one of the great achievements of internal fixation to have reduced the incidence of decubitus ulceration to 8 4 per cent We can say only that we are astonished In this series of one hundred patients, treated by traction, with ages ranging up to ninety-two years, there were three pressure sores

* **Tolerance of old people to recumbency**—To test the validity of this observation we have analysed the case records of all patients over the age of 60 years treated in recumbency in the orthopaedic wards at Raigmore Hospital during the past four years Number of patients over 60 years of age treated in recumbency 147 ages 60 to 92 years average age 69 9 years Time in hospital 1 day to 60 weeks average 55 days Period of recumbency 1 day to 53 weeks average 39 days Number of deaths 11 Mortality 7 5 per cent , average age 75 4 years Period of recumbency before death 1 to 203 days average 38 days Three died in the first week two in the second week Causes of death malignant disease, 2 post-operative shock, 2, cerebral haemorrhage 1, moribund on admission 2, hypostatic pneumonia 3 uraemia, 1 Of these eleven deaths only the last four can be related to recumbency Complications bed-sores, 4, psychoses, 3, pneumonia 3

FIG 16

Ununited subtrochanteric fracture (type 4) in a young man aged twenty-eight years, three months after injury Non-union was due to the penetration of muscle by the upper end of the shaft of the femur

Non-union—Several authors refer to the possibility that conservative treatment may cause non-union, and advance this as a reason for internal fixation (Moore 1944, Sins and Ryan 1944), but the complication is very rare indeed. King (1945) reports only two cases in ten years, and Stuck (1944) states that he has never seen a case of non-union in this region. In our own series there was one case of non-union in a subtrochanteric fracture in which operative exposure showed that the lower fragment had been driven through muscles and was completely separated from the upper fragment (Fig. 16). In this region we cannot agree with Watson-Jones (1943) that inadequate immobilisation is an important factor leading to failure of union. No trochanteric fracture treated conservatively by traction is "adequately immobilised" in the sense intended by Watson-Jones, and yet it is probably safe to say that 99 per cent. of these fractures unite, and often very rapidly (Figs. 9–12). We reject the view that the risk of non-union is an argument in favour of internal fixation.

Other complications—*Drop foot* occurred in nine cases. In one, it was due to fracture of the lateral condyle of the tibia with direct injury to the nerve. There were four cases of bilateral foot drop due to palsies unassociated with the fracture. In the other four cases the onset of paralysis must be attributed to the treatment—pressure of the splint or of the rotation bandage. All recovered.

Thrombophlebitis and pulmonary embolism—These complications appear to be more frequent after operative than conservative treatment. Cleveland *et al.* (1947) reported two deaths from pulmonary embolism after internal fixation, but none in the cases they treated conservatively. In discussion of the paper by Cleveland (1947), Dr Norton, while advocating internal fixation, described thrombophlebitis as a troublesome complication and reported five deaths due to pulmonary embolism. In the series reported in this paper there have been certainly two, and possibly three cases of thrombophlebitis. The first patient, a woman aged seventy-three years, made a satisfactory recovery, the second patient died from pulmonary embolism on the thirtieth day, and the third died suddenly on the twenty-fifth day, but no autopsy was permitted and the cause of death was not established.

Pneumonia—Most deaths after trochanteric fractures of the femur, whether treated conservatively or by operation, are due to pneumonia. Of the ten deaths in this series, seven were due to pneumonia. It is a grave complication, but the danger can be reduced by good nursing, maintenance of the correct position, and insistence on free movement in bed from the beginning. With conservative treatment in traction as it has been described, the patient is hardly more restricted than after internal fixation, and active mobility of the patient is interrupted even less than it must be for some hours or days after operation.

Wound infection can occur only after operation. It is futile for the supporters of operative treatment to claim that infection should not occur, for it *does* occur, and we fear that it may occur far more often than is generally recognised. Kellogg Speed (1945) wrote: "The frequency and gravity of post-operative infection following internal fixation for fractures of the neck of the femur are not appreciated because many instances are concealed and few are reported." He then quoted a sentence from an article by Sins and Ryan (1944): "If other surgeons have experienced the same disastrous consequences, we have not found any mention of it in the literature", and he went on to say: "Neither have I, yet I have been seeing and struggling with these calamities for several years." Sins and Ryan (1944) reported four infected wounds in sixty-one cases. Moore (1944) reported one wound infection in eighty-three cases. Cleveland *et al.* (1947) reported four infections in ninety-five operations, two due to infected haematoma with one death, and two fatal cases of gas gangrene.

Protrusion of the nail into the hip joint—It appears that frequent as bending and breaking of the nail plate may be, and often as screws may loosen, the incidence of penetration of the hip joint by the point of the nail is even greater. O'Brien *et al.* (1946) reported ten such disasters in a series of one hundred and three operations. Cleveland *et al.* (1947) also referred to the frequency of this complication.

Mortality—This we regard as the crux of the argument, and the most important point for discussion because, even if the claims for internal fixation are admitted, the benefits are not so great as to justify risking the life of the patient by a form of treatment that is not essential Most authors who favour operative methods claim that lives are actually saved by operation, and they support this claim by quoting comparative mortality rates for conservative and operative groups of cases (Table IV)

TABLE IV

Conservative treatment			Operative treatment		
Author	Cases treated	Percentage mortality	Author	Cases treated	Percentage mortality
			Morris (1941)	28	21 4
Leydig and Brookes (1940)	302	39 2	Siris and Ryan (1944)	100	22 0
Morris (1941)	16	44 0	Harmon (1945)	45	11 1
Harmon (1945)	164	39 0	O Brien *et al* (1946)	103	21 4
Cleveland *et al* (1947)	38	34 0	Cleveland *et al* (1947)	95	12 6
			Moore (1944)	83	No operative deaths

At first sight the evidence in favour of operation appears to be overwhelming, but it would be unwise to accept it without further inquiry In the first place we do not believe that the mortality figures for conservative treatment are truly representative of this type of fracture—certainly not in Great Britain In this series of one hundred cases, treated conservatively, there were ten deaths Looking back over previous years, and recalling a far greater number of cases, we do not think that the mortality was appreciably different Quite certainly it never approached the astonishing figures indicated in Table IV of one death in three patients This conviction is shared by many experienced surgeons with whom we have discussed the problem

The mortality rate of 10 per cent in the present series compares favourably with the operative mortality figures published, and is approached closely only by three of the series listed above in Table IV One of these (Moore 1944) should be dismissed at once On first reading Moore's paper we wondered what he meant when he said that " in eighty-three cases there were ' no operation deaths ' " because in Fig 9 he illustrated the case of a patient who died of pneumonia ten days after operation It was only after reading an earlier paper (Moore 1937) that it became clear that the author distinguishes " operation deaths " from " died during treatment " It is misleading and unfortunate that, in consequence, several authors have attributed to Moore a mortality of nil

The figures of Harmon (11 1 per cent) and Cleveland *et al* (12 6 per cent) are excellent, but if we are to judge from the literature they are exceptional Moreover, if these figures are to be compared with our own results the causes of death should be considered Harmon makes no analysis Cleveland attributes four of twelve deaths to operation, namely two cases of gas gangrene, one of operation shock, and one of pulmonary embolism But a fifth case died of pulmonary embolism, and a sixth died of inanition after infection of the haematoma—both of which might reasonably be attributed to the operation If, in a series with a mortality as low as 12 6 per cent , there were four deaths (and possibly six) directly attributable to the operation, it seems probable that in the more numerous series with mortalities above 20 per cent there must have been very many deaths due to operation In

addition to wound infection, pulmonary embolism, and post-operative pneumonia, surgical shock is clearly an important factor Moore (1944) denies this, and perhaps in his hands this is true for he states that the operation can be done comfortably in twenty to twenty-five

FIG 17

FIG 18

FIG 19

Comminuted intertrochanteric fracture (type 3) on admission (Fig 17) note early arthritic changes The position five days later after application of traction and internal rotation bandage is shown in Fig 18 One year later consolidation with slight loss of length yet clinically almost indistinguishable from normal (Fig 19)

minutes But the average surgeon cannot approach this time The operating time estimated by O'Brien *et al* (1946) was one and a half hours These authors frankly admit the part played by operative shock in causing death, especially in their earlier cases It is to be expected

that as a surgeon gains experience his operative mortality will be reduced. Thus Taylor *et al* (1944) described two groups of cases with a much higher operative mortality in the first than in the second series. In their earlier series of 165 cases, including 108 treated conservatively and fifty-seven by internal fixation, the mortality of the operation cases was 33 per cent. In their later series of 102 operations the mortality was reduced to 21.6 per cent. It can be concluded either that patients were selected more carefully or that surgical shock was reduced by improved technique. Is it then to be recommended that all surgeons should gain experience at the expense of a large number of lives and then forget about their first fifty cases? We would agree even with this if the operation could be proved necessary, but we think that our own results show this is not so.

Whatever the reason for the high mortality rates so often quoted in series of cases treated conservatively the manner of their comparison with operative mortality rates is open to criticism. A few authors claim to operate on all cases without selection, but it is clear that most surgeons do in fact select cases for operation. This must obviously be so because some patients are moribund on admission to hospital. Thus O'Brien *et al* (1946), in their report of 103 consecutive cases treated by internal fixation, excluded three who refused surgery and "four who for various reasons other than the fractures, were moribund on admission." These four deaths were excluded from the operative series and transferred to the conservative series, thus swelling the apparent mortality rate of conservative treatment and creating a wrong impression. Without doubt the worst cases are included in the conservative group, and even surgeons who intend to operate on every patient, in the belief that thereby they can save lives, are often prevented from doing so by the fact that the patient dies before they can operate. Taylor *et al* (1944) found that 25 per cent of deaths occurred in the first week, and most of these were cases not considered fit for operation.

Other methods of treatment—It is the authors' practice to avoid splintage except in subtrochanteric fractures. Details of the particular traction method used are not of great importance provided that the method permits adequate nursing and active exercises. We can well believe that Russell traction is excellent. Skeletal traction should seldom be necessary, and we cannot agree with Bartels (1939) who believes that 20 to 30 lb of skeletal traction should be maintained until union is established. Possibly he is right in claiming that this prevents coxa vara, but there is abundant evidence to show that heavy traction delays union and our own observations lead us to believe that slight shortening, especially in comminuted fractures, may hasten union without impairing function (Figs 17–19).

Plaster spica—On the other hand, we agree with Bartels regarding the use of a plaster spica, which will not prevent coxa vara if it is used in the treatment of fractures with displacement. It is evident from the literature that immobilisation in a plaster spica has been used widely for trochanteric fractures, and this may be one factor contributing to the high mortality figures of conservative treatment. We believe that a plaster spica has practically no place in the treatment of trochanteric fractures. It is far better to treat undisplaced fractures by light traction and concentrate on early movements, while in the treatment of displaced fractures traction is essential to reduce and prevent deformity. Fixation of both hips in wide abduction by means of below-knee plasters connected by a broomstick is similarly open to criticism. The object no doubt is to lock the fracture in the abducted position while leaving the patient free to sit up, but this method does not prevent coxa vara.

Well-leg traction—In the practice of the authors, "well-leg traction" has been abandoned as unsatisfactory. It is admitted that good reduction of the fracture can be maintained, and that the patient can be lifted out of bed, but this last advantage is offset by the fact that in bed he is far more restrained than with simple traction. Without a free leg he is helpless to move himself up and down. The method incurs a serious risk of bilateral knee stiffness, the second hip is fixed in an unphysiological position, and pressure sores are common.

External pin fixation has also given discouraging results The authors have experience of only one case of a trochanteric fracture treated in this manner Good reduction and fixation were obtained but what is often described by euphemistic writers as "seepage from the pin-tracks," and which we regard as frank sepsis, soon occurred The pins were removed before sepsis could extend deeper, and fortunately the patient made a good recovery, but this happy ending is not always the rule Siris and Ryan (1944) treated five trochanteric fractures and one intracapsular fracture of the neck of the femur by external pin fixation every single case was complicated by sepsis which resulted in the death of each of the five patients with trochanteric fractures Moreover the method may result in other complications, particularly pain at the site of the pin-tracks, and joint stiffness

SUMMARY

1 A series of one hundred consecutive cases of trochanteric fractures treated conservatively by the authors has been reviewed

2 Analysis of the results obtained and a study of the relevant literature has led us to the firm conclusion that the routine treatment of this group of fractures should be conservative

3 Internal fixation should be reserved for those exceptional cases where traction is found to be inadequate this is specially likely in cases associated with an upper motor neuron lesion, where difficulty is experienced in maintaining reduction owing to muscle spasm

4 The basal type of fracture offers a special problem because it merges imperceptibly into that of the true transcervical fracture No difficulty has been experienced in this series in the conservative treatment of such fractures, but we recognise that they might well be regarded as a variety of transcervical fracture and treated by nailing in order to avoid the risk of non-union

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BONE CONCAVITY CAUSED BY A GANGLION

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The origin of the "simple" ganglion has been discussed fully by Carp and Stout (1928) The view that these cysts arise from aberrant islands of synovial tissue, or from herniations through the linings of joints or tendon sheaths, has been abandoned for the reason that they are never lined with synovial endothelium, nor do they contain synovial fluid It is more likely that a ganglion is due to mucoid degeneration of the collagen of connective tissue possibly in consequence of injury The degenerative change begins in many microscopic centres which coalesce to form one or more cystic swellings lined by laminae of compressed fibrous tissue King (1931) made the interesting suggestion that a ganglion arose not by a process of degeneration but by primitive mucoid secretion of connective tissue cells, similar to that which occurs in the embryo in the formation of joint spaces A ganglion may of course have deep connections, but it does not usually involve the deeper structures and the report of a case in which there was considerable resorption of underlying bone may therefore be of interest

Fig 1

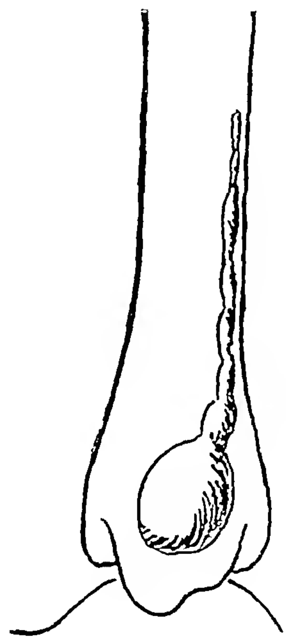

Fig 2

Radiograph of the ankle joint in May 1947 showing resorption of bone at the site of development of a ganglion (Fig 1) The line drawing shows the main cyst just above the medial malleolus with a slender extension upwards along the posterior tibial border (Fig 2)

Case Report—A Polish airman, aged forty-four years, was seen in May 1947 complaining of a cystic swelling of four years' duration in the region of the left medial malleolus There was a history of injury in 1942, and there had been aching pain for some time before the swelling was noticed Previous treatment by aspiration, and by attempted removal, had failed Radiographic examination in September 1945 showed a cup-shaped depression in the bone just above the medial malleolus, within which the tumour had been found to be lying when it was exposed at operation Histological section of the excised material was said to suggest a simple ganglion

On admission there was radiographic evidence of deep resorption of the tibia (Fig 1) At operation the previous scars were excised and the cystic swelling was defined It was one inch in diameter and contained pale yellow gelatinous fluid It was closely adherent to the periosteum which actually formed the deep wall of the cyst within the bone concavity

A lobulated part of the cyst extended upwards along the posterior border of the tibia for a distance of five inches (Fig 2) The whole tumour, with a margin of surrounding tissue, was removed in one piece The wound was closed without drainage and healing was uneventful Microscopical examination confirmed the diagnosis of ganglion (Fig 3) There was no evidence of recurrence five months later, the radiographic appearance was unchanged

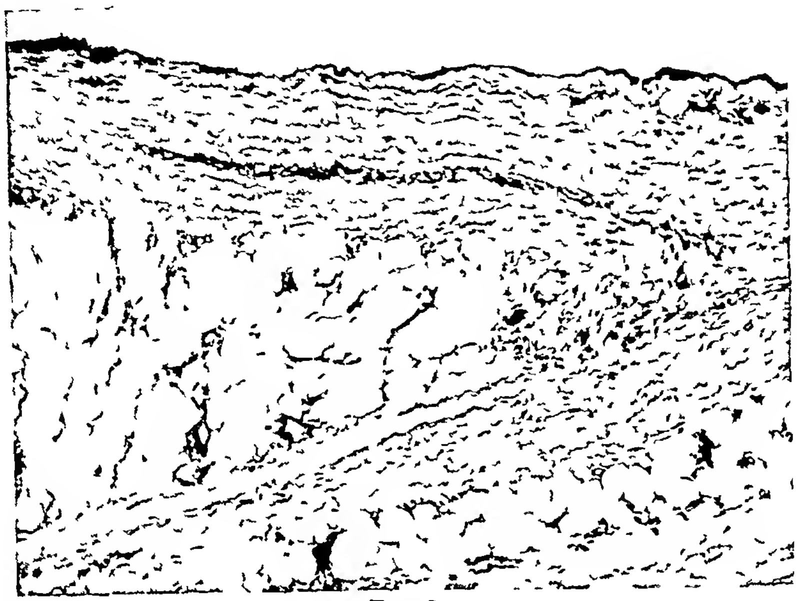

FIG 3

Microscopic section of the wall of the cyst showing that there is no lining with synovial endothelium The cell spaces in the wall of the cyst indicate the activity and mode of spread

Discussion—On clinical and histological grounds this cyst was undoubtedly an ordinary ganglion Recurrence of the swelling after attempted removal at a previous operation could be explained by failure to excise the cyst-bearing area completely, or by continued spread of the degenerative process The association of a simple ganglion with underlying bone change is unusual, and in a review of the literature I have been unable to find any record of a similar case Erosion of the head of the tibia by cysts of the semilunar cartilages has, however, been reported by Fairbank and Lloyd (1934), Ghormley and Dockerty (1943), and Watson-Jones (1948) It appears probable that in this case the ganglion arose from the periosteum and caused erosion of bone before bursting into the subcutaneous tissues This would explain the history of aching pain before the appearance of the swelling

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ISCHIO-FEMORAL ARTHRODESIS OF THE HIP BY POSTERIOR OPEN APPROACH

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I have been much impressed by the rapidity and solidity of the extra-articular fusion of the hip joint that develops after osteotomy of the upper femoral shaft with insertion between the cut femoral surfaces of a strong and wide tibial graft which is driven into th ischium, as described by Brittain (1942) During the years 1942–44 I carried out th procedure described by Trumble (1937) A tibial graft was inserted between the tuber isch and the shaft of the femur without osteotomy In a small series of cases, all much younger than those described by Trumble, I found that the results were disappointing because the graft nearly always failed to fuse at either the ischial or the femoral end Nevertheless, in performing Trumble's operation I was struck by the excellent view gained of the sciatic nerve, the upper femoral shaft, and the lateral aspect of the pelvis It seemed feasible to carry out the Brittain type of operation through this posterior approach under full vision, and with no risk of injuring the sciatic nerve The first operation was performed in November 1945 Since then it has been done in nineteen other cases

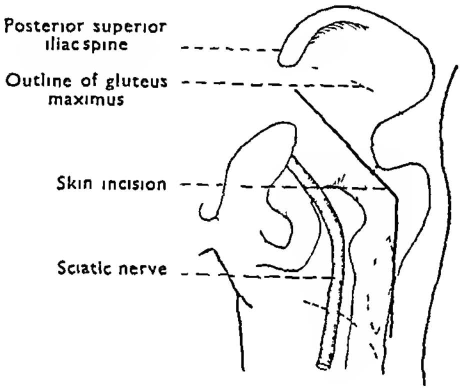

Fig 1

Diagram of the gluteal region showing line of skin incision (After Trumble)*

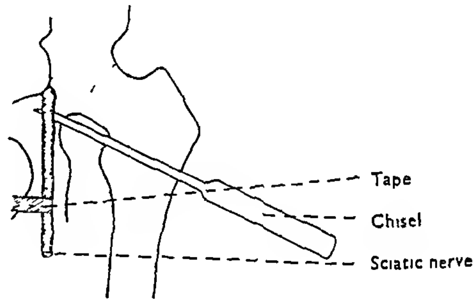

Fig 2

Diagram showing line of femoral osteotomy in relation to the pelvis and sciatic nerve

TECHNIQUE OF OPERATION

The patient is placed prone on the operation table, rather near to the operator's side so that the greater trochanter is easily accessible The limb on the affected side is draped separately so that it can be manipulated by the operator In earlier cases I used Trumble's skin incision, but this has now been modified as shown in Fig 1 It extends from near the posterior-superior iliac spine to the upper part of the great trochanter, with vertical extension downwards as far as may be necessary to give good exposure of the lateral aspect of the subtrochanteric region

The gluteus maximus muscle is split in the line of its fibres Part of its fascial insertion and the fascia lata are divided in the subtrochanteric region Wide retraction with self retaining retractors gives full exposure of the sciatic nerve, the lateral aspect of the pelv the posterior part of the greater trochanter and upper femoral shaft, and the origin of t

Editorial comment—To be anatomically accurate the sciatic nerve in Fig 1 should lie against the ischium The old surface marking half-way between the ischium and greater trochanter is quite wrong The anatomists tell us so and I have confirmed it both in the cadaver and at the operation here described Incidentally is this not the ordinary Kocher posterior approach to the hip joint and should it not be so described ? Assistant Editor

vastus lateralis (Fig 2) A tape is passed round the sciatic nerve so that it can be drawn gently backwards and medially The quadratus femoris muscle, which is often obvious at this stage, serves as a useful guide to femoral levels The angle between the under-surface of the femoral neck and the side of the pelvis is inspected It is often wise to palpate with the finger in order to confirm the level, and make sure that there is an area of good solid bone opposite the shaft of the femur, usually part of the pelvis below the acetabulum and above the obturator foramen In earlier cases I made the mistake of following Trumble's technique

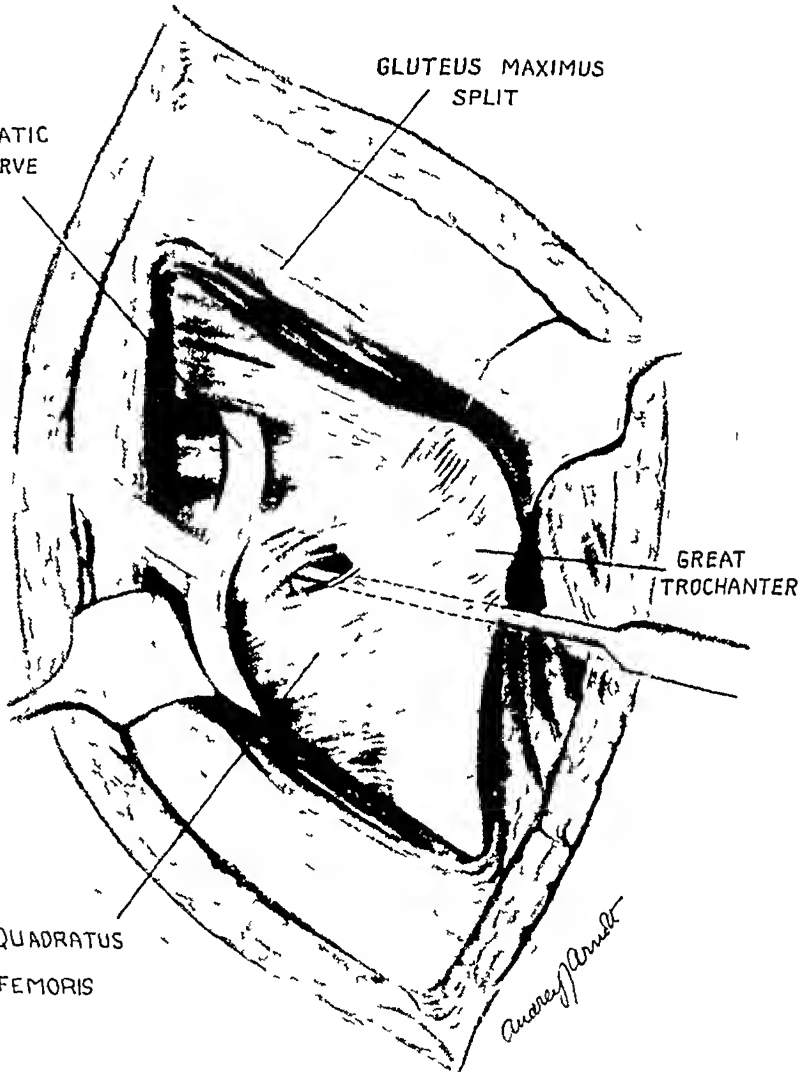

FIG 3

The operation area (semi-diagrammatic) Dissection of the short rotator muscles above the level of the quadratus femoris and below the neck of the femur gives adequate exposure of the lateral aspect of the pelvis

too closely and trying to place the graft posteriorly, towards the tuber ischii This led to difficulty in fitting the graft because the femoral shaft is always in a plane in front of the ischial tuberosity A point on the pelvis opposite the femoral shaft in the coronal plane must be selected (Fig 3) It does not in the least matter what particular anatomical part of the pelvis this may be, so long as it is below the level of the acetabulum, and that it offers a sufficient area of solid bone for adequate penetration of the graft When the line of the graft has been selected the vastus lateralis is split, and the periosteum of the femur is incised

FIG 4

FIG 5

Case 1 Male aged eleven years Old tuberculous arthritis of the right hip joint with fibrous ankylosis (Fig 4) Three months after operation there is evidence of bone fusion (Fig 5)

FIG 6

FIG 7

Case 2 Male aged twenty-one years Old tuberculous arthritis of the left hip joint with fibrous ankylo and adduction deformity (Fig 6) Two years later the radiograph shows hypertrophy of the bone brid (Fig 7) The adduction deformity has been corrected Fusion is also occurring across the joint itse

and retracted with bone levers so as to expose the subtrochanteric region The femur is divided completely with a sharp thin chisel or osteotome, and the instrument is driven on until it can be seen or felt in contact with the selected area of the pelvis When this has been confirmed, the chisel is driven in for a distance of from half to one inch

If it is so desired, a radiograph may then be taken to check the alignment of the chisel and the depth of its penetration into the pelvis Radiographic control is not essential because, even without it, both direction and penetration can be determined easily The chisel blade can be seen or felt entering the pelvis and, if its length is known, the depth of penetration can be calculated by subtracting the length of blade up to the point of entrance into the pelvis from the known total length It is still more simple to use a calibrated chisel The same principle applies to the graft itself, provided that it is cut to a known length Each of the first fifteen operations was done without radiographic control and later examination showed that there was no material error of direction or penetration of the graft Nevertheless, radiographs taken during operation do offer an additional safeguard, and more recently I have used them

The blade of the chisel should be approximately equal to the width of graft to be used —that is to say, the width of the subcutaneous surface of the donor tibia If the instrument used is too narrow it should be withdrawn and re-inserted in such a way as to lengthen the slot in the pelvis A second chisel can be driven in above or below the first, or a thicker bladed chisel substituted for it, in order to increase the size of the slot and facilitate engagement of the graft

The chisel is left in position, and the wound is covered with a sterile towel The opposite lower limb is then flexed at the knee joint and held by an assistant while a graft is cut in the manner described by Brittain The periosteum is incised over the subcutaneous surface, completely stripped from the bone, and held retracted by two pairs of bone levers at the upper and lower limits The length of graft should usually be five inches in an adult, and four inches in a child, thus leaving a short piece to be cut off after sufficient penetration of the pelvis has been obtained The vertical saw-cuts should be along the margins of the subcutaneous surface of the tibia so that the graft will be as wide as possible, the saw blade being held obliquely in order to penetrate the medullary cavity The ends of these longitudinal lines of section are joined by a transverse saw cut, vertical to the surface at the proximal end, but oblique at the distal end so as to bevel it

The bevelled end of the graft is engaged between the cut ends of the femur with its cortical surface towards the hip This stage is facilitated by longitudinal traction on the limb in order to distract the femoral fragments The graft is driven carefully along the upper surface of the chisel blade till it reaches the pelvis, the chisel is then withdrawn and the graft is hammered into the slot Alternatively the chisel may first be withdrawn and the graft be directed along its track Penetration of the pelvis should usually be about one inch in adults and half an inch in children, this being checked by subtracting from the known total length of graft the distance measured from its free end to the point of pelvic penetration A second radiograph may be taken in order to confirm the level and penetration of the graft The projecting end is then removed with the motor saw, flush with the lateral surface of the femur, and the fascial, muscular and skin incisions are sutured

At the end of the operation it will be found that the graft and upper femoral fragment are stable, but that the upper end of the lower fragment of the femur is fairly mobile against the under surface of the graft This allows the surgeon to place the limb in the best position for fusion It was sometimes thought that if the patient were turned to the supine position for the application of plaster there might be some risk of displacing the fragments This has been avoided by applying a plaster spica with the patient in the prone position—which offers no special difficulty but calls for care in judging the position of the hip accurately If post-operative radiographs show that an error has been made in alignment of the limb, this can

be corrected by sectioning the plaster and swinging the limb into the position of choice—a procedure that has been necessary in only two cases in this series After eight or ten weeks the plaster spica is changed In all but two cases there has at that time been firm clinical union with no detectable movement, or pain on handling In nearly every case radiographs have shown union of the osteotomy At this stage a short single spica with knee-jointed caliper extension to the shoe has been used, so that the patient can walk with normal knee action This is retained for a further two months, or until there is radiographic evidence of sufficient fusion and consolidation to allow external support to be discarded Illustrative radiographs are shown in Figs 4–7

SUMMARY OF RESULTS

Ischio-femoral arthrodesis by posterior open approach has been performed in twenty patients Of these, one is still in hospital and is therefore excluded In the other nineteen patients, operation was undertaken for tuberculosis of the hip joint in seventeen, and for osteoarthritis of the joint in two There has been no mortality and no wound infection

Age of youngest patient	8 years
Age of oldest patient	52 years
Average age	19 years
Longest follow-up period	3 years
Shortest follow-up period	8 months
Average follow-up period	20 months

There has been failure of fusion in only one case, that of an obese patient, aged fifty-two years, with osteoarthritis nevertheless the functional result is satisfactory In all other cases there was clinical and radiographic evidence of sound fusion In practically every case this fusion was present at the time of removal of the first plaster, about ten weeks after operation In a number of patients, especially the younger, there was some evidence of operative shock, and transfusion of blood or plasma during the operation is a wise precaution

SUMMARY

1 An operation is described for ischio-femoral extra-articular arthrodesis of the hip joint by posterior open approach, based on the techniques of Trumble and Brittain

2 The operation has the advantages of affording adequate exposure of the sciatic nerve trunk and permitting visual control of the alignment and penetration of the chisel and graft

3 The operation has been performed successfully without serious shock or subsequent complications in eighteen cases, mostly of tuberculosis of the hip

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NEUROFIBROMA OF THE SOLE IN A CASE OF VON RECKLINGHAUSEN'S DISEASE

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J H, a miner, aged forty-four years, complained of a painful swelling on the sole of his foot He said that this, and numerous other lumps on his body, had been present as long as he could remember The tumour had recently become painful, but he did not think that it had changed in size

FIG 1

FIG 2

Case of von Recklinghausen's disease with many soft skin tumours (Fig 1), and a neurofibroma of the sole (Fig 2)

On examination he was found to be a typical case of von Recklinghausen's disease Numerous soft skin tumours, varying in size from a few millimetres to two centimetres in diameter, were found on his trunk, limbs, neck, and scalp (Fig 1) He showed typical pigmentation The tumour of the foot was well defined, soft in consistency and slightly tender (Fig 2) It was removed on September 16, 1948, and the histological report (for which I am indebted to Dr C Clarke) stated that it was a typical neurofibroma

The *reason for publishing this case is that it refutes the statement* made by von Recklinghausen in his original description of the condition in 1882, and frequently repeated by other writers, that these tumours (" molluscum fibrosum ") do not occur in the palms of the hands or the soles of the feet

I am grateful to Mr F W Holdsworth for his permission to publish this case

SKIN GRAFTING BY CROSS-LEG FLAPS

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Destruction of the skin and subcutaneous tissues of the lower limb is often associated with injury to underlying tendons or bone Sometimes the skin lesions are allowed to heal by granulation, or they are closed more rapidly by the application of split-skin grafts, and the results of such treatment may be entirely satisfactory But healing by granulation often leads to chronic ulceration, and healing by split-skin grafting may yield an inadequate and unstable surface, ischaemia developing in each case in consequence of the strangling effect of scar tissue The importance of securing adequate skin cover before undertaking bone reconstruction operations was impressed repeatedly upon orthopaedic surgeons during the recent war The most satisfactory skin cover is gained by means of a skin flap that includes subcutaneous tissue, and a whole-thickness skin flap which gains vascular supply from its margins and through its base may improve the nutrition of underlying tissues In the case of the leg and foot a convenient donor area is provided by the opposite lower limb, and a flap applied direct from one lower limb to the other is known as a *cross-leg flap*

Blood supply of flaps—The blood vessels of the skin form a complex pattern and they may be divided into three main units The first lies in proximity to the papillary layer of the skin and is connected by vertical branches with arterioles of the subdermal and subcutaneous systems There is also a mid-dermal plexus which is chiefly, but not entirely, venous in constitution A third plexus, which is situated immediately beneath the dermis, hypertrophies greatly in tube pedicles and open flaps and appears to carry the major burden of vascular nutrition These facts suggest that, in skin, there is a plexus of vessels with collateral circulation which can be maintained despite such ischaemia as may occur during the raising of a flap Each of the three vascular systems is superficial to the subcutaneous fat and, unless inclusion of fat is specifically indicated, most of it may be discarded safely

Design of flaps—In planning a cross-leg flap five important considerations must be borne in mind 1) the basic relative positions of the limbs, 2) the size and shape of the lesion to be covered, 3) the ultimate purpose or function of the flap, 4) the site of the donor flap and disposition of its base, and 5) the age of the patient and vascular nutrition of the limbs

Basic position of the two limbs—It is seldom necessary to use "acrobatic positions" The recipient area must of course be brought close to the donor area but the position should be easy to maintain and tolerable to the patient

Size and shape of the lesion—The limbs are placed in one of the basic positions (Fig 1) and the flap is designed on the donor limb in the situation that is most suitable It is often wise to visualise the completed operation and then to reverse the steps of the procedure (Gillies 1932) The area of skin loss should be outlined carefully, and a replica be cut accurately from jaconet or tinfoil, making allowance for the increase in size of the lesion that always occurs after excision of the scar tissue The length of flap should equal the width of the deficiency plus the length of its "bridge" (Figs 2 and 3) An outline is drawn on the donor limb by reversing the jaconet pattern, due allowance being made for the "bridge"

Future purpose of the flap—The general purpose of a flap is to cover an area where skin is lost, or where the quality of skin cannot serve the purpose required of it If the flap is to cover a weight-bearing area it must include sufficient fat, but not too much For weight-bearing purposes the thickness of the fat layer should not be greater than 0 5 cm

Site of the donor area and disposition of its base—In a flap that is well planned the donor area should never encroach upon the tendo Achillis or the anterior surface of the tibia

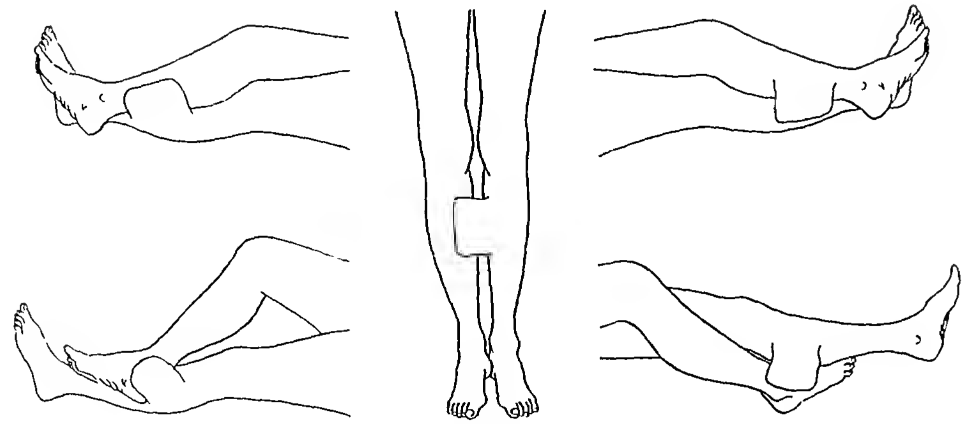

FIG 1

The five basic positions of the lower limbs as used for cross-leg flaps

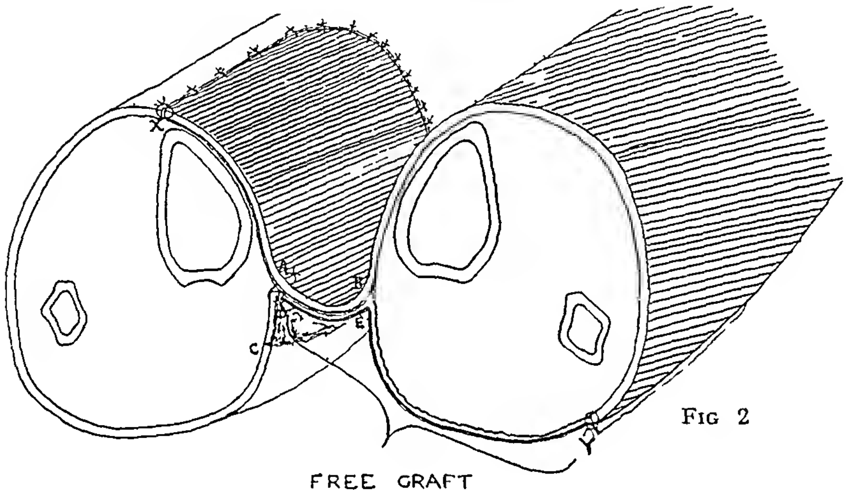

FIG 2

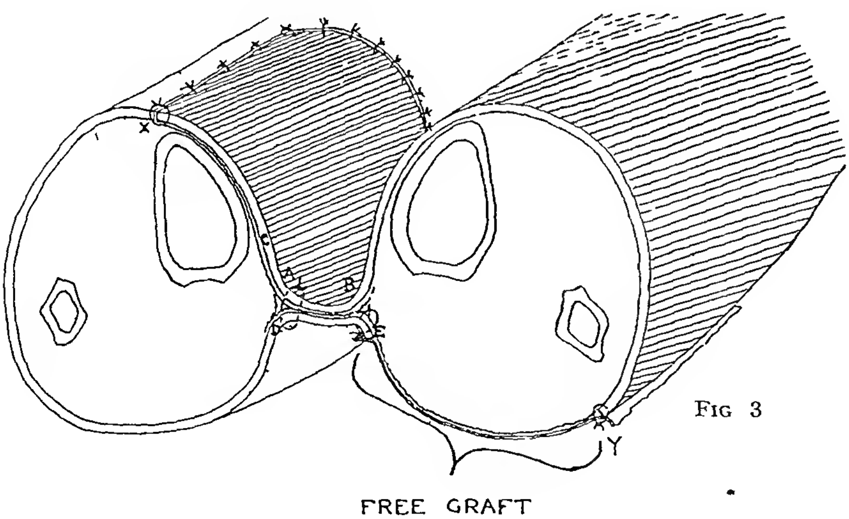

FIG 3

Alternative methods of lining the bridge with skin in order to minimise the risk of infection Fig 2 shows the technique when the scarred area (XC) is wide the posterior part (AC) is excised at the detachment stage and covered with skin from the bridge of the flap (AB) meanwhile the bridge as well as the doner area is covered with a free graft Fig 3 shows the technique when the scarred area (XC) is smaller a flap of normal tissue (DE) is turned back from the recipient limb to line the bridge of the flap

If this principle is not observed, and the transferred flap fails to "take," the surgeon may be faced with the necessity of planning further operations to repair the defect he has created as well as the original defect Whenever possible the skin flap should be taken from the fleshy part of the calf, and for direct transfer the base should measure not less than two-thirds the length

Age of the patient and vascular nutrition of the limbs—The age of the patient is less important than his general condition This statement has limitations but, in general, a healthy man of fifty years will yield a more healthy flap than a young man who is recovering from the effects of a long-infected compound fracture At the same time it must be recognised that, although the cross-leg position is often well tolerated by patients in middle age, convalescence may be prolonged by resulting stiffness of the knee joints and muscle wasting of the limbs

FIG 4

FIG 5

FIG 6

Case 1 Cross-leg flap for ulceration of leg due to chronic osteomyelitis The outline is marked out on the skin (Fig 4) After raising the flap the donor area is covered by a split-skin graft (Fig 5) The legs are brought together and the flap is sutured to the recipient area after excision of all scar tissue (Fig 6)

Delayed transference of flaps—Delay in transference of the flap is sometimes imperative The object of such delay is to encourage hypertrophy of the vessels of the sub-dermal plexus and thus improve the nutrition of the flap Available methods include 1) complete elevation of the flap and simple resuture in its original bed, 2) incomplete elevation of the flap, leaving a bridge of tissue at its extremity which is divided after an interval of ten to fourteen days The first method has little to recommend it If it is safe to raise a flap completely it is safe to transfer it at once The second method is better and it should be adopted if the flap is based distally, if the patient is physically old or relatively unfit, if there is vascular insufficiency of the lower limbs, or if the length/base ratio of the flap exceeds 3 2 In elderly patients, and those with vascular insufficiency, it is wise to arrange postural vascular exercises for some time before cutting the flap

Indications and contra-indications for cross-leg flaps—Skin grafting by cross-leg flaps is indicated for simple unstable scars of the leg and foot, unstable scars associated with chronic osteomyelitis or old compound fractures of the leg and foot, irradiation burns unstable scars of the leg or foot due to burns or frost-bite, trophic ulceration, old varicose

ulcers which are adherent to the tibia, painful scarred areas in weight-bearing areas, and scarred or unstable skin in regions where reconstructive operations are needed such as bone grafts, tendon reconstructions or nerve grafts

Cross-leg flaps are unsuitable in young women, children, and the aged They are unsuitable for very small lesions They should not be used when "acrobatic" positions of the limbs would be necessary, when there is arthritis of the knee or hip joints, or in patients of unstable mentality *Young women*—In young women it is inadvisable from the aesthetic point of view to use the calf of the sound limb as a donor area because the resulting scar is always visible It is better to use abdominal pedicles or "indirect flaps" *The aged or physically old*—These patients, especially when their mentality is unstable, do not tolerate the discomfort of an unusual position, nor do they easily withstand the several operations that are needed Moreover their joints become stiff, muscles waste, and pressure sores occur It is better, if possible, to close the defect by a free skin graft in spite of the deficiences of such grafts

Fig 7

Fig 8

Case 2 Unstable scar encircling the leg eighteen months after injury (Fig 7) Attachment stage of cross leg flap is seen in Fig 8 Because of the excessive length/breadth ratio double delay was necessary to ensure vitality of the flap

Children—Young children are often distressed by the postural restrictions needed for a cross-leg flap Skin deficiencies should be closed by free skin grafts—a method of repair that is more satisfactory in children than in older patients Alternatively a flap may be transposed from an adjacent area in the same limb with free grafting of the secondary defect *Very small lesions*—In small lesions transposition of a full-thickness flap from the same limb, with free grafting of the secondary defect, should be the method of choice *Lesions of the knee and hip joints*—When there is chronic arthritis of the knee joint replacement of skin by means of a cross-leg flap is contra-indicated because immobilisation, even for three weeks, may cause joint stiffness which is difficult to overcome

Maintaining the cross-leg position—The required position can be maintained by simple crepe bandages, plaster-of-Paris bootees and crêpe bandages, or plaster-of-Paris splints including the knee joint and thigh Each of these methods has its merit and its indication, but immobilisation in plaster splints appears to be the method of choice The purpose of fixation is to maintain proximity of the donor and recipient areas, and to minimise strain on the flap Bandages alone may not suffice and if they are used special care must be taken to prevent pressure sores between the limbs

When plaster fixation is to be employed the splints should be applied the day before operation with the limbs in one of the basic positions The plaster should be applied separately to each limb in such a manner that a sufficient area is left free round the donor and recipient regions After operation the two casts are joined together by wooden struts fixed by means of plaster bandage If plaster is first applied after the operation is completed, when the muscles of the limbs are lacking in tone and the position must be maintained by assistants, great care and attention is needed if harmful tension on the flap is to be avoided, and it is sometimes difficult to secure the most comfortable position in which there is least danger of pressure sores The fact that the thigh may be covered by a plaster, applied before operation, so that it is no longer available as a donor site for the free graft needed to cover the area from which the flap is taken, is not a serious objection The skin of the abdomen is still available and it has many advantages

The attachment stage—A flap is raised from the donor area according to the outline that has been marked out Deep fascia is not included with the flap Unless the subcutaneous fat is very slight the flap is thinned The donor area is then covered by a split-skin graft, and pressure is maintained by oversewing a flavine wool dressing It is recommended that the "bridge" area of the flap should also be lined by means of a split-skin graft, or by a small direct flap from the recipient leg, so that the smallest possible area of the flap shall remain raw and exposed (Figs 2 and 3) The recipient area is excised and all scar tissue is removed The flap is then applied to the deficiency and it is sutured to its margins

FIG 9

FIG 10

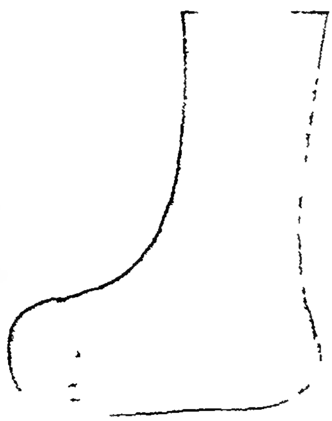

FIG 11

Case 3 Crushed foot with loss of toes Chronic ulceration of a transferred flap due to inadequate excision of scar tissue before application of the flap (Fig 9) After thorough excision of scar tissue a further cross-leg flap has been applied (Fig 10) with a satisfactory end-result (Fig 11)

The area of attachment of the flap should be not less than 60 per cent of its total area In Fig 2 the recipient area extends from X to C The flap XAB covers only the extent XA, leaving scar tissue over the area DC to be excised later The donor area YE, and the "bridge" area DE, are covered by free skin graft In Fig 3 the deficiency XC on the recipient limb is smaller than in Fig 2, and a flap of normal tissue DE can be turned back from the recipient limb to line the bridge of the flap Each method ensures that infection is minimal, and that the bridge remains supple and easy to manipulate during the detachment stage If the bridge is not grafted it becomes infected, hard, oedematous, and covered by sprouting granulations *Sutures*—Vertical mattress and simple everting stitches of fine waxed silk are used Suture material stronger than this is not required If this technique is followed it is impossible to

suture a flap under tension Small anchoring sutures are used to fit the flap snugly into concavities on the recipient site

Complications—The three major complications are haemorrhage under the flap, infection of the flap, and necrosis of the flap

Haemorrhage—With adequate care this complication can usually be avoided Bleeding is often venous and due to pressure from a bandage applied tightly round the limb proximal to the field of operation If a haematoma forms under the flap, or under the graft covering the donor area, the haematoma should be evacuated in the operating theatre and the bleeding point secured

Infection—If the recipient area is a chronic ulcer, slight infection may take place Nevertheless the resistance of cross-leg flaps to infection is high The presence of B Pyocyaneus, B Proteus

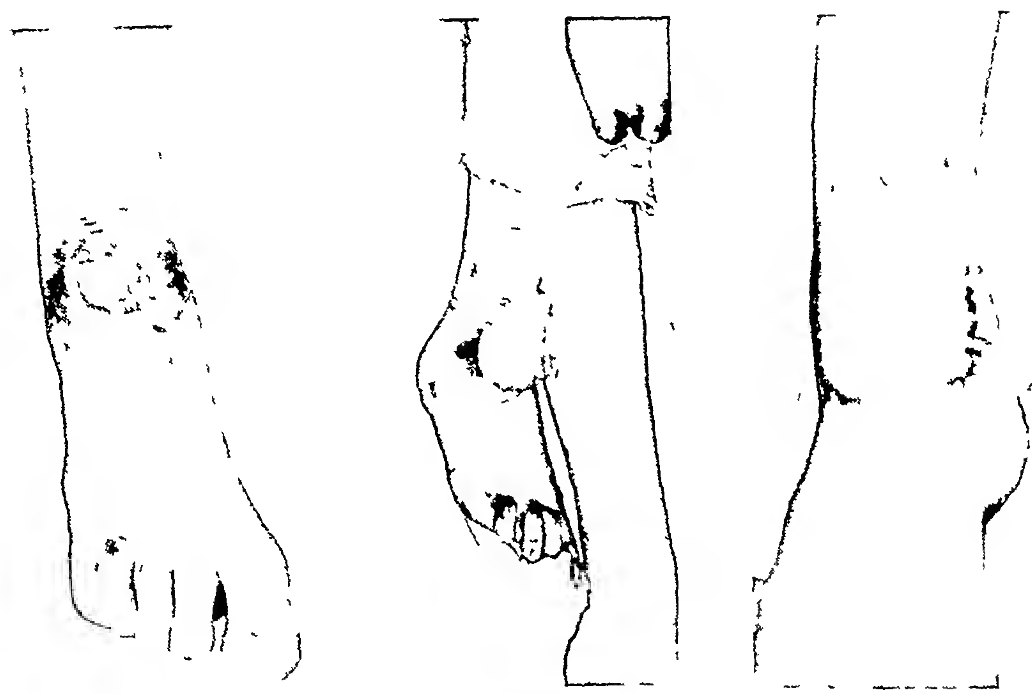

FIG 12 FIG 13 FIG 14

Case 4 Chronic ulceration over the front of the ankle after compound fracture with disorganisation of ankle joint (Fig 12) Arthrodesis must be deferred until satisfactory skin cover has been secured Fig 13 shows the attachment stage of a cross-leg flap The condition shortly after detachment of the base is seen in Fig 14

r B Coli is not necessarily harmful The potentially dangerous invaders such as haemolytic treptococcus and staphylococcus can be controlled by the use of systemic penicillin

Necrosis of the flap—Necrosis is usually due to interference with the blood supply of the flap yanosis is often the first indication, most flaps dying in congestion and not in pallor The auses of necrosis are *a*) haematoma forming under the flap, *b*) bad adjustment of the elative positions of the limbs, or inadequate fixation of the limbs, leading to kinking of the ridge, *c*) constriction of the base of the flap due to pressure by bandages or dressings, or o badly placed stitches *d*) inadequate removal of scar tissue from the recipient area

Difficulties in the attachment stage—During the attachment stage difficulties may arise owing to the nature of the surface to be covered It is more difficult to cover a concave surface than a convex or flat surface Concavity of the recipient area is usually due to loss of bone, for example a saucerised cavity in the subcutaneous surface of the tibia In such a case the cavity may first be filled with bone chips in order to improve the seating of the flap If this method is used certain precautions are necessary 1) sclerosed bone lining the cavity must be removed thoroughly, 2) the flap should be larger than the bone cavity in

FIG 15

FIG 16

FIG 17

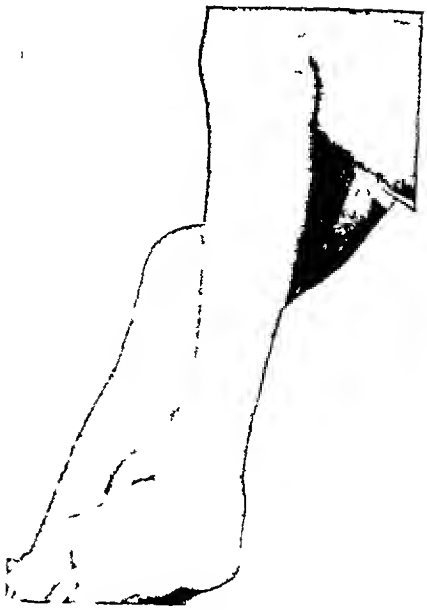

FIG 18

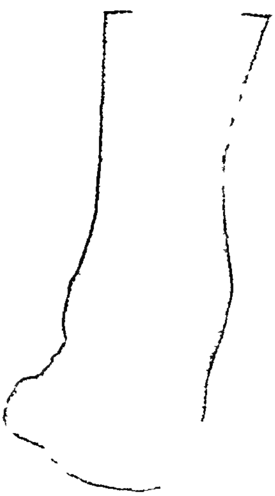

FIG 19

FIG 20

Case 5 Persistent ulceration over the heel and front of the ankle resulting from pressure sores in a prisoner-of-war (Figs 15 and 16) Double flaps were marked out on the opposite calf (Fig 17) Cross-leg flaps were applied simultaneously to the two areas of skin-loss (Fig 18) with a satisfactory result (Figs 19 and 20)

order that it may gain sufficient nutrition from around it, 3) the flap must cover the whole deficiency so that the operation is "closed", 4) the chips must be of cancellous bone and include no cortical bone which might sequestrate

The detachment stage—The flap must not be divided earlier than three weeks after its attachment The confining bandages or plasters are then removed and the limbs are held in position until the base of the flap is severed The line of section depends upon the condition under which the flap was attached (Figs 2 and 3) If the conditions are as in Fig 2 the flap is divided at B, the scar CD is excised and AB is seated into the deficiency caused after excision of its covering free skin graft If the conditions are as in Fig 3 the part AB is returned to the donor limb and such parts of DE as may be required are returned to the recipient limb After the detachment stage light pressure is applied to the area by encircling crêpe bandages

Post-operative management—The day after operation, exercises are practised once more In older patients some stiffness of the knee joint is usual, but as a rule full movement is regained quickly A crêpe bandage is applied to both lower limbs for four weeks, thus preventing oedema Walking is resumed after ten to fourteen days, but direct transmission of weight through transferred flaps should be delayed for six to eight weeks, crutches being used meanwhile Even after that, transferred flaps that carry weight should be protected by sorbo pads until sensation is restored

Flaps on the feet sometimes show vascular abnormalities such as cyanosis or persistent coldness Cross-leg flaps with such changes may be divided into 1) flaps applied upon bases from which scar tissue has been excised inadequately, 2) flaps applied upon limbs with post-traumatic peripheral vascular abnormality, 3) flaps applied to limbs with vascular abnormality present before injury If the foot and leg as a whole is warm, and only the flap is cold and blue, the cause is inadequate excision of scar tissue before the flap was applied, and the cyanosis and coldness will usually disappear when the scar softens If impairment of circulation is the result of injury the condition often improves within about two years of injury Lumbar sympathectomy is sometimes of value, particularly in patients who complain of burning pain in the region of the original injury Active use of the limb is helpful in overcoming disuse atrophy Pre-existing vascular disease should, of course, have been dealt with before plastic surgery was undertaken

SUMMARY

1 After limb injuries with loss of skin and subcutaneous tissue, full-thickness skin flaps afford the most satisfactory cover It is particularly important to replace unstable and scarred skin before attempting bone reconstruction and similar operations

2 In the leg and foot, full-thickness skin cover is conveniently obtained by the cross-leg flap technique The blood supply of such flaps is considered and the technique of operation is described Free excision of avascular scar tissue is essential

3 "Delayed transfer" of the flap is advisable unless conditions are favourable, two methods are considered

4 Immobilisation in plaster is the most satisfactory method of fixation of the limbs after attachment of the flap Muscle exercises are performed throughout the period of treatment in order to minimise joint stiffness and shorten convalescence

5 The cross-leg flap technique should not usually be used in children, young women, or the aged and mentally infirm Contra-indications include arthritis of the knee and hip joints because there is danger of joint stiffness

6 Vascular complications of cross-leg skin grafting are discussed

The authors wish to thank Sir Archibald McIndoe for his help and also Mr Robin Dale for his diagrams and Mr Gordon Clementson for his photographs

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THE PATHOLOGY OF OSTEOCLASTOMA OR GIANT-CELL TUMOUR OF BONE

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Changing views as to the nature of this tumour have led to a diverse and confusing terminology—myeloma, myeloid sarcoma, *tumeur à myeloplaxes,* benign giant-cell tumour osteoclastoma and "chronic (non-suppurative) hemorrhagic osteomyelitis" being only some of the names applied to it Most of these terms are inappropriate and should be discarded —myeloma and myeloid because the tumours are not derived from any constituent of bone-marrow, Nelaton's *tumeur à myeloplaxes* because the tumour giant-cells are certainly not megakaryocytes, and Barrie's "chronic hemorrhagic osteomyelitis" because its falsity was exposed promptly by Stewart in 1922 Giant-cell tumour is a non-committal and satisfactory name, so long as it is not invariably linked, as Bloodgood linked it in 1924, with the adjective *benign*

The term "osteoclastoma" was first used in Great Britain by Stewart in 1922 and was later adopted by most British pathologists There now seems little room for doubt that this expresses correctly the histogenesis of the tumour The close similarity between the tumour giant-cells and the larger osteoclasts of bone-resorptive lesions, the identity of appearance of the tumour tissue with that of the masses of mingled fibroblastic and osteoclastic tissue in hyperparathyroidism (often wrongly called osteoclastomata for this very reason), and the conspicuous bone-resorptive effect of the tumours, together afford conclusive evidence of the osteoclastic nature of the tumour cells There are still those who, like Jaffe *et al* (1940), object to this view and prefer the histogenetically neutral name "giant-cell tumour" This purely descriptive, non-histogenetic name is satisfactory, but in my view the objection urged by Jaffe and others against the term osteoclastoma are of little weight

It must be added that the name osteoclastoma does not necessarily imply specific derivation from differentiated osteoclasts, for the osteoclast is not an immutable self perpetuating kind of cell The structure and development of bone, both in normal and in pathological states, show plainly that the several types of cells concerned in the formation and modelling of bone—chondroblasts, skeletal fibroblasts, osteoblasts and osteoclasts— are not distinct invariable species, they are readily interconvertible, even in adults In particular, it is clear that osteoblasts and osteoclasts are but functional variants of cells of the same type When these cells, by virtue of ambient conditions, are functionally concerned in elaborating alkaline phosphatase and laying down new bone, or in actively maintaining bone already there, they are osteoblasts, when by virtue of ambient conditions they are concerned in bone resorption, they are osteoclasts The osteoblast of to-day may be the osteoclast of to-morrow, and *vice versa*, and this reversal of function probably amounts to no more than slight alteration in the nature or quantity of the enzymes formed by the cells Dawson and Struthers (1923) showed that normal osteoclasts are formed by syncytial fusion of fusiform or stellate mononucleated cells In bone-resorptive areas it is often clear that many of these are osteoblasts, recently liberated from their calcified matrix The development of osteoclasts by aggregation of smaller cells is reflected in the structure of the osteoclastoma, which consists of a mixture of large multinucleated and small fusiform or polyhedral mononucleated cells Since osteoblasts and osteoclasts are no more than reversible functional phases of cells of the one kind, we might conveniently call them all "bone formative cells" An osteoclastoma is a tumour of these cells in which the functional bias is osteoclastic rather than osteoblastic

Age, sex and site incidence of osteoclastoma—*Age*—Most large series of cases, for example those of Kolodny (1927) and Christensen (1925), show that about two-thirds of these tumours develop before the age of thirty years, the greatest number being in the third decade Young children and the elderly are seldom affected, the youngest and the oldest patients in Kolodny's series were aged six years and sixty-eight years respectively Stewart also reported an example from a child six years old *Sex*—Males and females are about equally affected, females preponderating slightly (Kolodny 1927, Christensen 1925) *Site*—About half the tumours arise in bones of the lower limb, and one-quarter in the upper limb With few exceptions they occur at the ends of the bones The commonest sites in order of frequency are the distal end of the femur, proximal end of the tibia, distal end of the radius, proximal end of the humerus, distal end of the ulna, and proximal end of the fibula The remaining 25 per cent of tumours arise in bones of the head and trunk Lord and Stewart (1943) gave special reference to osteoclastomata of the skull

It has been stated by Kolodny (1927), Jacobson (1940) and Jaffe (1940), that giant-cell tumours often start in, or predominantly involve, an epiphysis, and it has even been suggested that they should be called epiphysial giant-cell tumours This idea, which has arisen for no other reason than that the tumours show a striking predilection for the ends of long bones, is incorrect An osteoclastoma in a young bone with an epiphysis that is not yet fused is situated not in the epiphysis but in the metaphysis, the epiphysial line is intact, as in the case of the children reported by Stewart (1922) and Burlend and Harries (1924), and in the specimen depicted by Martin (1930) which is still preserved in the Hunterian Museum of the Royal College of Surgeons of England (Fig 1) Even in Kolodny's own account, in which he upheld an epiphysial origin, the radiographs depicted in figures 93 and 98 of his article afford evidence against this view Two illustrations of giant-cell tumours by Illingworth and Dick (1941—figures 64 and 65) show that the tumours were situated in the metaphyses

Fig 1

Specimen of cystic osteoclastoma of tibia in a girl aged fourteen years showing the epiphysis intact except for a small breach of the epiphysial cartilage The specimen, presented by H A Lediard in 1911 is still in the Museum of the Royal College of Surgeons of England

Structure of the osteoclastoma—Young healthy tumours are uniformly red, brown, or sometimes pale, they are usually soft and friable Older tumours are altered by fibrosis, cyst formation, haemorrhage, pigmentation, yellow necrosis or calcification Early expansion of the bone tends to be uniform in all directions, but later it may become irregular and eccentric Not infrequently, tumours of the lower end of the femur begin in one or other condyle A prevalent impression that the radiographic appearances, and especially the multilocular or "soap-bubble" appearances, of osteoclastomata are distinctive, is erroneous, similar appearances can be produced by other expanding non-osteogenic tumours *Microscopical structure*—The microscopical features of healthy parts of the tumour are characteristic The admixture of fusiform or rounded cells and multinucleated giant cells, and the absence of any signs of osteoid or bony differentiation, is unlike that of any other bone tumour The giant cells measure up to 100μ or more in diameter and each possesses many

nuclei, sometimes as many as fifty in a single section (Figs 2 and 3) These nuclei are identical with those of the mononucleated cells, and there are appearances that suggest that giant cells are formed by fusion of the mononucleated cells Mitotic figures may be found in small numbers in the mononucleated cells, but they are seldom if ever found in the giant cells The vascularity varies greatly, the vascular channels are thin-walled, and the tumour cells abut closely on them Secondary changes are often conspicuous, including haemorrhages, cysts, areas of pigmentation or fibrosis, and accumulations of lipoid-laden foam cells These changes give older tumours a variegated appearance

Behaviour of the osteoclastoma—In most osteoclastomas, with characteristic clinical and histological findings, the tumours pursue a benign course, grow slowly, do not transgress

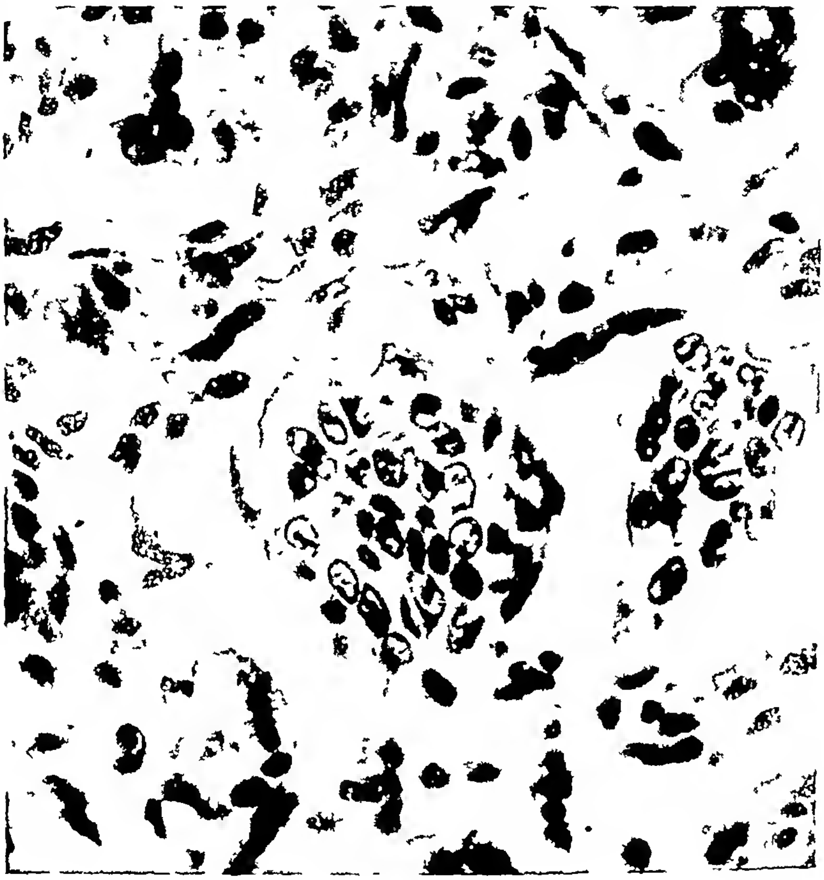

FIG 2

Microscopic structure of osteoclastoma showing multinucleated giant cells and smaller mononucleated fusiform or polyhedral cells (×650)

the periosteum, do not metastasize, and are curable by local removal Nevertheless, as was insisted by Stewart, incomplete removal is followed by recurrence Moreover, some tumours do transgress the bone cortex and periosteum, and invade surrounding tissues Lord and Stewart (1943) described an osteoclastoma of the temporal bone which invaded the external ear and the transverse sinus, and infiltrated the cerebellum There are now many reports of osteoclastomata that have metastasized to lymph glands, lungs or other parts (Willis 1934, Korchow 1933, Jaffe *et al* 1940) King and Jaffe *et al* have attempted to correlate the cytology of the tumours with their prognosis

Several writers have supposed that when a giant-cell tumour runs a malignant course sarcomatous change has supervened in a tumour that formerly was benign This is an unwarranted assumption, and it is based on the prevalent but erroneous idea that a sharp separation can be made between " innocent " and " malignant " tumours The truth is that

osteoclastomata, like most other groups of tumours, show a range of structure and behaviour, and that a few, not initially distinguishable from their benign fellows, invade and metastasize. This malignant behaviour does not presuppose any essential change of growth, it is a property, *ab initio*, of certain members of the class. In some malignant cases, for example those reported by Finch and Gleave (1926) and Dyke (1931), the structure of the metastases did not depart greatly from that of tumours of benign behaviour.

Chondromatous osteoclastomata—These rare tumours resemble ordinary osteoclastomata in the rate of growth, and the radiographic appearance, but when cut the tissue is found to be partly or wholly cartilaginous. Codman (1931) described nine such tumours, all in the upper end of the humerus. They may occur also in other situations, for example

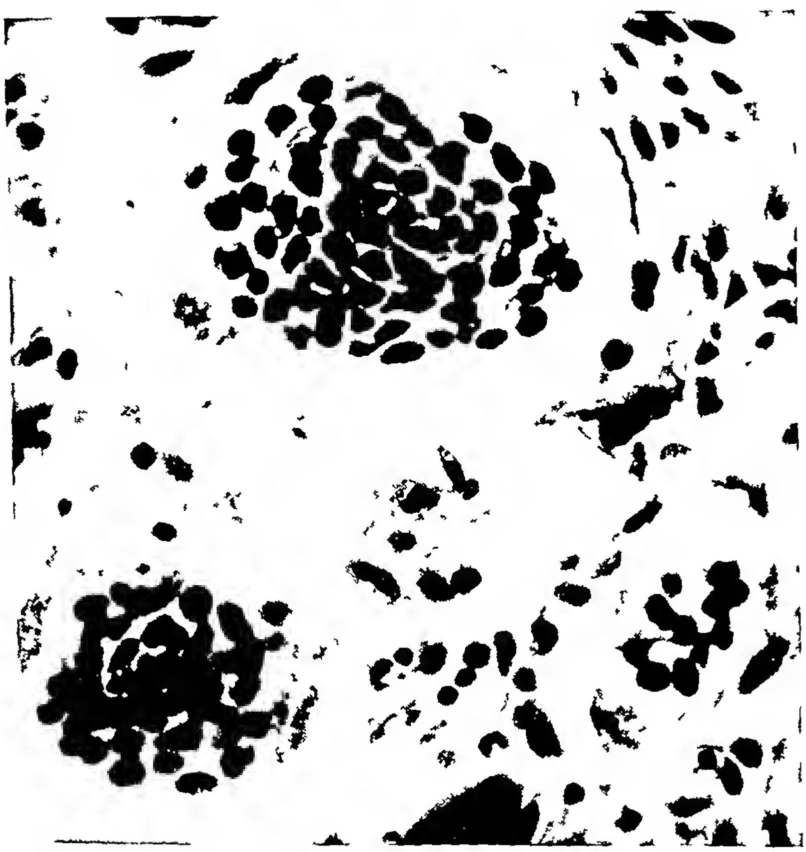

Fig. 3

Osteoclastoma giant cells containing more than fifty nuclei in the plane of section (×650)

in the tibia (Willis 1948). Microscopically they show areas of giant-cell tissue, identical in appearance with that of osteoclastoma, but mixed more or less intimately with cartilaginous tissue and with transitions between the two. From their structure it appears that the cartilage cells and the cells of the osteoclastomatous areas are the same, differing only in the presence or absence of a cartilaginous matrix. We are thus forced to the conclusion that proliferating chondroblasts and osteoclasts are related and mutually interconvertible. Jaffe and Lichtenstein (1942) deny that this kind of tumour is related to the ordinary giant-cell tumour, they regarded such tumours as "benign chondroblastomata" with incidental inclusion of giant cells. Nevertheless in the case that I have examined, as in Codman's cases, the structure appeared to me to show clearly that a cartilaginous variant of genuine osteoclastoma does indeed exist.

Lesions resembling osteoclastoma—Masses of tissue with a close structural resemblance to osteoclastoma, and often called "osteoclastoma," are found in generalised osteitis

fibrosa (hyperparathyroidism), and less commonly in localised osteitis fibrosa Such masses are not true tumours even when they attain large size, as in the case described by Mathers and Cappell (1938) They have no power of independent progressive growth and they disappear when the bone reforms

The close resemblance of osteoclastoma tissue to masses of osteoclastic tissue in bone resorptive lesions is no more surprising than the close resemblance of chondroma to normal cartilage, or of some osteosarcomas to reparative osteoid tissue At the same time, the very fact that the tumour tissue can resemble reactionary osteoclastic tissue perfectly, is itself good evidence that the former is indeed osteoclastoma

"Myeloid" epulides should not be grouped indiscriminately with osteoclastomata because, again, resemblance does not denote identity In many epulides the giant-celled tissue is clearly no more than inflammatory granulation tissue The giant cells are often smaller and less regular than those of osteoclastoma, they vary in number, and there is often phagocytic inclusion of haemosiderin Most epulides, both "myeloid" and fibrous, are granulomas they are non-invasive, very often they do not recur even after incomplete removal, and sometimes they retrogress spontaneously Rarely, true tumours—osteoclastomata or fibro sarcomata—may arise from the jaw or its periosteum, but these should be distinguished from the ordinary non-neoplastic epulis

Giant-celled tumours of synovial tissues also should be distinguished from osteoclastomata, which indeed they seldom resemble The structure of synoviomata is very variable—giant-celled fibrous, cartilaginous, bony, mucinous, or mixtures of these The common giant-celled tenosynovioma is often also fibromatous The structure, as well as the situation, of these tumours in relation to tendon sheaths and *not* tendons, disproves the contention of Geschickter and Copeland (1936) that they arise from sesamoid bones

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TREATMENT OF GIANT-CELL TUMOURS OF BONE

With a Review of Twenty-five Cases

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Giant-cell tumour of bone is well recognised as a clinical and pathological entity but survey of the literature shows that there is much variation of opinion as to the relative merits of treatment by surgical intervention and irradiation In this paper, which includes a review of twenty-five cases, an attempt has been made to assess the value of these methods

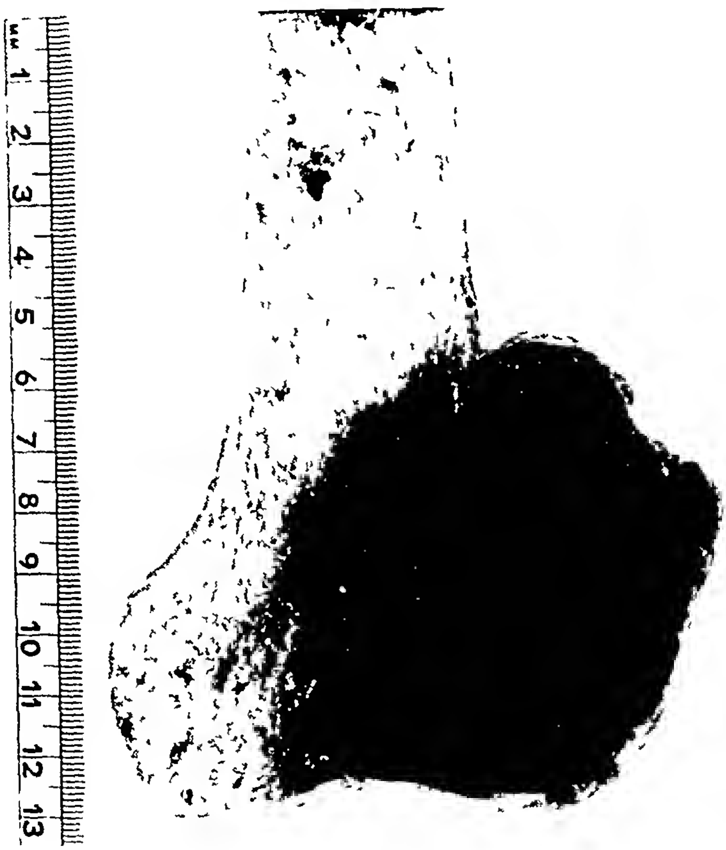

FIG 1

Macroscopic specimen of benign giant-cell tumour involving the epiphysial and juxta-epiphysial region at the lower end of femur

HISTORICAL NOTE

Lebert (1845) first described giant cells in medullary tumours, but tumours of this type were known earlier They were described by Cooper and Travers in 1818 Robin (1850) reported benign tumours of bone with many giant cells Sir James Paget (1853) introduced the name " myeloid tumour " Nelaton described forty-six cases in 1860 Both Nelaton and Paget believed that the tumours, though usually benign, could recur after removal and might become malignant Gray (1856) thought that the condition was always benign Bloodgood (1910, 1912) emphasized the benign nature and recommended that the tumours should be treated conservatively, in 1919 he reported forty-seven cases cured by curettage and bone grafting, and he proposed the term " giant-cell tumour " Geschickter and Copeland

(1930, 1936), reporting 105 cases treated by curettage, said that there was recurrence in thirty-one cases, sixteen of which were cured after a second or third operation Meyerding (1945) reported forty cases treated by excision and bone grafting with excellent results

The treatment of benign giant-cell tumours by irradiation has been recommended increasingly during the last two decades (Herendeen 1924, 1926, 1931, Coley 1927, Kolodny 1927, Pfahler and Parry 1932, Ewing 1940, Cade 1940, 1941, Cade *et al* 1947, Coley 1942, Mercer 1944, Shorvon 1946) In 1943 Brailsford said that the diagnosis could be established by radiography alone, and that biopsy was neither necessary nor desirable, irradiation was the treatment of choice, but Mandeville and Howe (1944) emphasized the need for reports of proved cases treated by irradiation alone and said that "until such reports are made Roentgen therapy cannot be properly evaluated or considered the treatment of choice for giant-cell tumours of the long bones"

How then is the lesion to be treated? Should it be treated by surgery alone or by irradiation alone? Should surgery and irradiation be used together? Should surgery be used in some cases and irradiation in others?

CASE RECORDS

Case 1 Female, aged 5 years, under the care of Sir Stanford Cade *History*—December 1941 radiographic evidence of recurrence of benign giant-cell tumour of the upper end of the left humerus removed by curettage six months previously *On examination*—Smooth painless swelling of the upper end of the bone movements of the shoulder joint full and painless *Treatment*—High voltage X rays tumour dose 1170r The patient is well to date under observation for six years, no interruption of bone growth at the epiphysis

Case 2 Male, aged 14 years, under the care of Dr F M Allchin *History*—1938 pathological fracture of the upper end of the right humerus radiographs showed benign giant-cell tumour, treated by curettage and bone graft sustained a second pathological fracture in November 1944, radiographs showed recurrence of the tumour *On examination*—Smooth, hard tender swelling of the surgical neck of the right humerus *Treatment*—December 1944, high voltage X-rays tumour dose 2000r in three weeks pain disappeared one month later radiographs showed early recalcification which was complete in three months Well and free from symptoms to date under observation for three years

Case 3 Male, aged 16 years, under the care of Dr F M Allchin *History*—In 1936, when aged 7 years a symptomless benign giant-cell tumour of the upper end of the right femur was treated by curettage and bone graft well until 1942 when there was recurrence with pain radiographs showed absorption of the graft *On examination*—Wasting of the muscles of the thigh, limitation of movement of the hip joint tenderness on palpation *Treatment*—High voltage X-rays First course June 1942 tumour dose 2000r in three weeks pain relieved recalcification noted Second course February 1943 tumour dose 2000r in three weeks Third course December 1943 teleradium unit tumour dose 2300r in eight weeks Fourth course March 1946 high voltage X-rays, tumour dose 1000r in two weeks Has been well since under observation for three years

Case 4 Female, aged 33 years, under the care of Dr F M Allchin *History*—January 1941 pain and swelling of the left side of the mandible radiographs showed large benign giant-cell tumour of the body and ramus of the mandible, removed by curettage February 1942 recurrence of tumour *On examination*—Firm, smooth tender swelling of the body and angle of the left mandible skin and mucous membrane normal *Treatment*—High voltage X-rays First course February 1943, tumour dose 2000r in three weeks, radiographs showed recalcification Second course July 1943, tumour dose 2000r in three weeks, pain diminished with further calcification Third course, October 1943 teleradium unit tumour dose 2100r in three weeks, tumour shrank to half original size July 1947, no evidence of recurrence

Case 5 Female, aged 25 years, under the care of Mr G T Mullally *History*—April 1944 complaint of pain in the right thumb first noticed two weeks earlier while wringing clothes *On examination*—Fusiform swelling of the thumb metacarpal which was tender firm, and smooth pain on movement of joints, radiographs showed expansion and rarefaction of the bone (Fig 2) progressive increase of symptoms *Treatment*—Tumour removed by curettage histological examination confirmed the diagnosis of giant-cell tumour, swelling soon reappeared in six weeks it reached the size of a small orange High voltage X rays first course, June 1945, tumour dose 1894r in two weeks subsequent shrinkage of lesion and evidence of

recalcification Second course October 1945 tumour dose 876r in one week Third course, January 1946 tumour dose 1460r in two weeks considerable regression Still swelling of the thumb and little movement but no pain the lesion appears to be quiescent

Case 6 **Female, aged 45 years,** under the care of Sir Stanford Cade *History*—November 1938, pain in the right hip of increasing severity, September 1939, swelling in the region of the right buttock November 1939 excision of benign giant-cell tumour, diagnosis confirmed histologically *On examination*—Large, smooth slightly tender tumour of the right ischium reaching the inguinal ligament above and the lesser trochanter below skin over the tumour normal, all movements of the hip joint limited *Treatment*—First course March 1940, high voltage X-rays, tumour dose 620r in one week Second course, April 1940 teleradium unit tumour dose 4429r in five weeks pain progressively less, radiographs showed shrinkage and recalcification sinus persisted for several months but closed by August 1941 Has remained well to date, under observation for eight years

Case 7 **Male, aged 14 years,** under the care of Dr F M Allchin *History*—1945, pathological fracture of the right humerus *On examination*—Smooth tender swelling of the upper end of the humerus skin over the tumour normal, movements of the limb full and painless radiographs showed giant-cell tumour of the upper end of the right humerus *Treatment*—High voltage X-rays First course November 1943, tumour dose 1400r in four weeks symptoms relieved January 1944 radiographs showed considerable recalcification Second course, May 1944, tumour dose 1400r in two weeks April 1945 radiographs showed increasing calcification Patient remained well until August 1947 when he died from poliomyelitis

FIG 2

Case 5 Radiograph of benign giant-cell tumour of the metacarpal of the right thumb The thin bone shell is absent in places

Case 8 **Female, aged 56 years,** under the care of Dr F M Allchin *History*—1944 pain and swelling of the left side of the jaw of several months' duration *On examination*—Firm smooth tender swelling of the left lower jaw radiographs showed a benign giant-cell tumour of the body and ramus of the mandible *Treatment*—Teleradium unit first course January 1944 tumour dose 2400r in three weeks marked shrinkage of tumour pain diminished Second course July 1944 tumour dose 2400r in two weeks One month later pain gone radiographs showed recalcification of the translucent area Well to present time, under observation for four years

Case 9 **Male, aged 37 years,** under the care of Dr F M Allchin *History*—1941, increasing pain and difficulty in movement of the left knee *On examination*—Hard tender swelling fixed to bone at the upper end of the left tibia, skin over tumour normal radiographs showed benign giant-cell tumour *Treatment*—High voltage X-rays, first course October 1941 tumour dose 2640r in two weeks pain but little relieved Second course February 1942 tumour dose 2850r in two weeks some recalcification but pain persisted Third course, March 1943 tumour dose 2160r in three weeks pain relieved but still present recalcification increasing Fourth course January 1944 teleradium unit tumour dose 2331r in two weeks After the last course there was considerable relief radiographs showed marked increase of calcification but never complete November 1947 severe pain recurred there was fluid in the joint radiographs showed articular cartilage ruptured amputation advised

Case 10 **Male, aged 32 years,** under the care of Sir Stanford Cade *History*—1945 pain in the left cheek one month after injury to the maxilla radiographs showed benign giant-cell tumour of left maxillary antrum *Treatment*—Curettage followed by high voltage X-rays tumour dose 1800r in four weeks, no recurrence Radiographs now show consolidation of the maxilla the antrum is clear, well to date, under observation for three years

Case 11 **Female, aged 19 years,** under the care of Dr F M Allchin *History*—1940 complained of pain in back tuberculous disease of the spine suspected *On examination*—May 1941 fullness in the right

loin at the level of the third lumbar vertebra, a mass could be felt, surface of the tumour smooth fixed to deep structures, firm and slightly tender, no limitation of movement of the lumbar spine radiographs showed giant-cell tumour of the right side of the body and transverse process of the fourth lumbar vertebra *Treatment*—High voltage X-rays First course, June 1941, tumour dose 2000r in five weeks August 1941 radiographs showed shrinkage of tumour and recalcification Second course, February 1942 tumour dose 1250r in four weeks further recalcification Third course, November 1942, tumour dose 1250r in four weeks Patient has remained well and free from symptoms to date tumour calcified

Case 12 Female, aged 41 years, under the care of Dr S P Meadows *History*—September 1943 progressive weakness of both legs incontinence of urine and faeces, pain in left leg for five months *On examination*—Large cystic tumour palpable over sacrum, easily felt by rectal examination Wasting and weakness of ham-strings, calves and anterior tibial muscles, ankle jerks absent, knee jerks present sensory loss over the areas supplied by S 1, 2 3, 4 albumen in urine but no Bence Jones protein radiographs showed complete destruction of the sacrum with no new bone formation *Treatment*—October 1943 teleradium unit tumour dose 3135r in three weeks no significant improvement, general condition deteriorated rapidly, died three weeks later Autopsy showed that death was due to pyelonephritis and oedema of the lungs no metastases

Case 13 Female, aged 34 years, under the care of Dr F M Allchin *History*—October 1944 pain left arm after injury radiographs showed pathological fracture of the radius through a benign giant-cell tumour, treated by high voltage X-rays elsewhere *On examination*—May 1946 swelling upper end of radius with limitation of elbow movements skin over the tumour normal *Treatment*—May 1946, high voltage X-rays, tumour dose 1540r in two weeks pain relieved but recalcification slow January 1948 movements almost normal radiographs showed little evidence of reossification, but pain has disappeared and the limb can be used without discomfort

Case 14 Male, aged 18 years, under the care of Sir Stanford Cade *History*—June 1947 while boxing felt pain in the left arm *On examination*—Smooth, painless swelling at the upper end of the radius radiographs showed benign giant-cell tumour (Fig 3) *Treatment*—High voltage X-rays tumour dose 2044r in two weeks January 1948 pain relieved, increasing calcification

Case 15 Female, aged 15 years, under the care of Dr F M Allchin *History*—1945 fracture left arm after a fall Further fracture September 1947 from trivial violence radiographs showed pathological fracture through benign giant-cell tumour of the upper end of the left humerus *Treatment*—High voltage X-rays tumour dose 2044r in two weeks no pain fracture healing, recalcification progressing rapidly

FIG 3

Typical appearances of benign giant-cell tumour at the upper end of the radius showing expanded cystic area surrounded by thin bone shell Trabeculation is also seen

Case 16 Male, aged 36 years, under the care of Sir Stanford Cade *History*—Increasing pain in the right knee for six months *On examination*—April 1944, smooth, tender tumour of the medial femoral condyle, radiographs showed giant-cell tumour *Treatment*—High voltage X-rays tumour dose 3080r in five weeks regression of tumour recalcification of translucent area Symptomless to date, under observation for four years

Case 17 Male, aged 39 years, under the care of Sir Stanford Cade *History*—September 1943 fracture of the surgical neck of the right humerus due to a fall from a bicycle previously the shoulder had been persistently painful *On examination*—August 1944 tender swelling of the upper end of the right humerus movements of the joint painful and limited radiographic appearances typical of benign giant-cell tumour *Treatment*—High voltage X-rays tumour dose 1980r in three weeks September 1944, good recalcification of bone, symptomless to date, under observation for three years

Case 18 Male, aged 27 years, under the care of Sir Stanford Cade *History*—Increasing pain in the left hip for two years after injury *On examination*—October 1943, pain and limitation of movement of

left hip smooth, tender tumour upper end of left femur, radiographic appearances typical of benign giant-cell tumour *Treatment*—High voltage X-rays First course November 1943 tumour dose 2000r in four weeks Second course, May 1944, tumour dose 2178r in four weeks, regression of tumour, recalcification of bone Symptomless to present time, under observation for four years

Case 19 **Male, aged 13 years,** under the care of Dr F M Allchin *History*—Increasing pain in the right shoulder for three months *On examination*—November 1944, smooth, tender swelling of the upper end of the right humerus, movements of the joint limited, radiographic appearances typical of benign giant cell tumour with pathological fracture *Treatment*—High voltage X-rays, tumour dose 1444r in three weeks regression of tumour, recalcification of translucent area, pain relieved Well to date, under observation for three years

Case 20 **Male, aged 33 years,** under the care of Sir Stanford Cade *History*—November 1943, increasing pain in the left hip for one year *On examination*—All movements of the joint limited, slightly tender, smooth tumour at upper end of the left femur, radiographs showed benign giant-cell tumour *Treatment*—February 1944, high voltage X-rays, tumour dose 1800r in five weeks, pain disappeared and movements of the joint became normal little evidence of recalcification, pain recurred after eight months Second course, November 1944 tumour dose 1800r in four weeks, pain relieved, regression of tumour, recalcification in translucent area Still slight pain calcification not complete, able to carry on sedentary occupation without discomfort

Case 21 **Male, aged 33 years,** under the care of Dr F M Allchin *History*—October 1941, injury to the right knee which became swollen and painful swelling gradually increased *On examination*—Firm, tender swelling of the upper end of the tibia skin over the tumour normal, radiographs showed benign giant-cell tumour *Treatment*—Teleradium unit first course November 1943, tumour dose 2950r in three weeks tumour became smaller and pain was relieved, but radiographs showed little evidence of recalcification Second course, May 1944, tumour dose 2450r in four weeks, one month later recalcification progressing rapidly Patient is well all movements of the knee full and painless, under observation for four years

Case 22 **Female, aged 36 years,** under the care of Sir Stanford Cade *History*—1936 "felt something snap" in the right hip, and subsequently noticed discomfort and swelling of gluteal region *On examination*—Firm tender swelling over the medial and upper aspects of the right thigh skin over the tumour normal movements of the hip joint painful and limited, radiographs showed benign giant-cell tumour of the right pubis and ischium *Biopsy*—Benign giant-cell tumour *Treatment*—June 1938, teleradium unit, tumour dose 3255r November 1938 considerable regression of tumour recalcification proceeding rapidly January 1939, hip movements normal patient symptomless to date, under observation for ten years This case has been reported previously (Nissen 1939)

Case 23 **Female, aged 17 years,** under the care of Dr F M Allchin *History*—Fell on ice rink September 1942, some weeks later increasing pain in the right hip *On examination*—July 1943 large soft tumour with rounded edges attached to the right ilium skin over the tumour normal, movements of the hip joint normal radiographs showed a giant-cell tumour involving right ilium *Biopsy* confirmed the diagnosis *Treatment*—First course, August 1943 high voltage X-rays, tumour dose 2300r in five weeks, one month later tumour smaller the tumour continued to shrink, but radiographs showed little evidence of recalcification Second course January 1944 teleradium unit, tumour dose 3240r in three weeks, tumour became smaller, edges more definite, the treatment caused temporary amenorrhoea Patient well and symptomless to date under observation for five years

Case 24 **Male, aged 22 years,** under the care of Mr G H McNab *History*—September 1941 swelling of the left lower jaw of six months duration *On examination*—Hard smooth painless tumour attached to the body of the mandible left side palpable from within the mouth fixed to bone, radiographs showed benign giant-cell tumour subsequently confirmed histologically *Treatment*—High voltage X-rays tumour dose 1500r pre-operatively, tumour removed by curettage Symptomless to date under observation seven years

Case 25 **Male, aged 39 years,** under the care of Sir Stanford Cade *History*—September 1942 pain in the left knee for one year swelling for one month *On examination*—Movements of the joint painful smooth, tender swelling of the head of the left fibula radiographic appearances typical of benign giant-cell tumour *Treatment*—High voltage X-rays First course, October 1942 tumour dose 2600r in five weeks Second course April 1943 tumour dose 2135r in four weeks pain relieved regression of tumour recalcification of translucent area Symptomless to date under observation for four years

Case No	Incidence		Clinical feature			Surgical treatment	Histology	Result	Treatment by irradiation			Result	Remarks
	Sex	Age	Trauma	Presenting symptoms	Site				First course	Second course	Third course		
1	F	5	No	Pain	Upper end left humerus	Curettage June 1941	Benign giant-cell tumour	Recurrence Dec 1941	H V X-rays 1170r			Good	Function normal Well to date—6 years
2	M	14	Yes	Pathological fracture	Upper end left humerus	Curettage and bone graft 1938	Benign giant-cell tumour	Recurrence Nov 22 1944	H V X-rays 2000r			Good	Function normal Well to date—3 years
3	M	16	No Found when X-rayed for swallowed f b	Symptom-less	Upper end right femur	Curettage and bone graft 1936	Benign giant-cell tumour	Recurrence 1942	H V X-rays 2000r	H V X-rays 2000r	Teleradium 2300r 4th course 1945 H V X-rays 1000r	Good	Function normal Well to date—3 years
4	F	33	No	Pain	Left side mandible	Curettage Jan 1941	Benign giant-cell tumour	Recurrence Feb 1942	H V X-rays 2000r	H V X-rays 2000r	Teleradium 2100r	Good	Function normal Well to date—4 years
5	F	25	No	Pain	First right metacarpal	Curettage Feb 1945	Benign giant cell tumour	Recurrence within 6 weeks	H V X-rays 1894r	H V X-rays 876r	H V X-rays 1460r	Fair	Regression of tumour No pain Swelling still present
6	F	45	No	Pain	Right ischium	Partial removal by curettage	Benign giant-cell tumour		H V X-rays 620r	Teleradium 4429r		Good	Function normal Well to date—8 years
7	M	14	Trivial	Pathological fracture	Upper end right humerus	Nil			H V X-rays 1400r	H V X-rays 1400r		Good	Patient died from poliomyelitis There was no evidence of the tumour 4 years
8	F	56	No	Pain	Mandible left side	Nil			Teleradium 2400r	Teleradium 2400r		Good	Function normal Well to date—4 years
9	M	37	No	Pain	Upper end left tibia	Nil			H V X-rays 2640r	H V X-rays 2850r	H V X-rays 2160r	Failure	Pain recurred and joint involved Amputation advised
10	M	32	Yes	Pain	Left maxilla	Curettage	Benign giant-cell tumour	Recurrence	H V X-rays 1800r			Good	Good consolidation Function normal Well to date—3 years
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Fourth lumbar	Nil			H V X-rays [illegible]	H V X-rays [illegible]	H V X-rays [illegible]	[illegible]	Regression of tumour with [illegible]

				incontinence urine	Sacrum	(Biopsy)	giant cell tumour		3135r			Fail	e admission and died of pyelonephritis
13	F	34	Yes	Pain and pathological fracture	Upper end left radius	Nil			H V X-rays	H V X-rays 1540r		Fair	No pain—but incomplete recalcification—18 months
14	M	18	Yes	Pain	Upper end left radius	Nil			H V X-rays 2044r			Good	Pain disappeared Recalcification progressing
15	F	15	Yes	Pathological fracture	Upper end left humerus	Nil			H V X-rays 2044r			Good	No pain Fracture healing and recalcification progressing
16	M	36	No	Pain	Medial femoral condyle (left)	Nil			H V X-rays 3080r			Good	Regression of tumour Pain disappeared Well—4 years
17	M	29	Yes	Pain	Upper end right humerus	Nil			H V X-rays 1980r			Good	Regression of tumour No pain Well—3 years
18	M	27	Yes	Pain	Upper end left femur	Nil			H V X-rays 2000r	H V X-rays 2178r		Good	No pain Good calcification Normal function Well—4 years
19	M	13	Yes	Pain	Upper end right humerus	Nil			H V X-rays 1444r			Good	Pain disappeared Recalcification rapid Symptomless —3 years
20	M	33	No	Pain	Upper end left femur	Nil			H V X-rays 1800r	H V X-rays 1800r		Fair	Still has pain and recalcification not complete
21	M	33	Yes	Pain and tumour	Upper end right tibia	Nil			Teleradium 2950r	Teleradium 2450r		Good	No pain Regression and recalcification of tumour Function normal—4½ years
22	F	36	Yes	Pain	Right ischium	Biopsy	Benign giant-cell tumour		Teleradium 3255r			Good	Rapid regression of tumour with calcification and loss of pain Well—10 years
23	F	17	Yes	Pain	Right ilium	Biopsy	Benign giant-cell tumour		H V X-rays 2300r	H V X-rays 3240r		Good	No pain Regression of tumour with calcification Well to date—4½ years
24	M	22	No	Tumour	Left side mandible	Curettage	Benign giant-cell tumour		H V X-rays 1500r			Good	Symptomless Well to date —6 years
25	M	39	No	Pain	Upper end left fibula	Nil			H V X-rays 2600r	H V X-rays 2135r		Good	No pain Regression of tumour with recalcification Well—5 years

CLINICAL FEATURES

Incidence—Benign giant-cell tumour of bone, although not common, is by no means rare, it accounts for 20 per cent of all bone tumours (Cade *et al* 1947) The American Registry of Bone Sarcoma (Kolodny 1927) recorded one giant-cell tumour for every two sarcomata—an incidence higher than that of most other records

Sex and Age—Of the cases reported in this paper fourteen were males and eleven females, and other recorded series show an almost equal sex incidence The condition may occur at any age but the greatest frequency is between the ages of twenty-five and thirty years, the peak age being about one decade higher than that of osteogenic sarcoma and Ewing's tumour The youngest patient in this series was a girl of six years, and the oldest was a woman of fifty-six years One case has been reported in an infant aged four months (Proffitt and Wyatt 1946)

Site—Any bone in the skeleton may be involved The tumour usually occurs in long bones and the site of election is the epiphysis or juxta-epiphysial region (Fig 4) It has been estimated that bones of the lower extremity are involved in 56 per cent of cases (Kolodny 1927), but the humerus, pelvic bones and scapula may also be affected The lower end of the radius, and the short bones of the hands and feet, though infrequent sites for osteogenic sarcoma, are not uncommonly involved In this series there was one tumour of the transverse process and body of the fourth lumbar vertebra, and one of the sacrum The disease is not uncommon in the jaw and has been described in the skull (Giffin and Love 1945) Benign giant-cell tumours of sesamoid bones have been reported by Faltin (1924), King and Towne (1929), and Shorvon (1946)

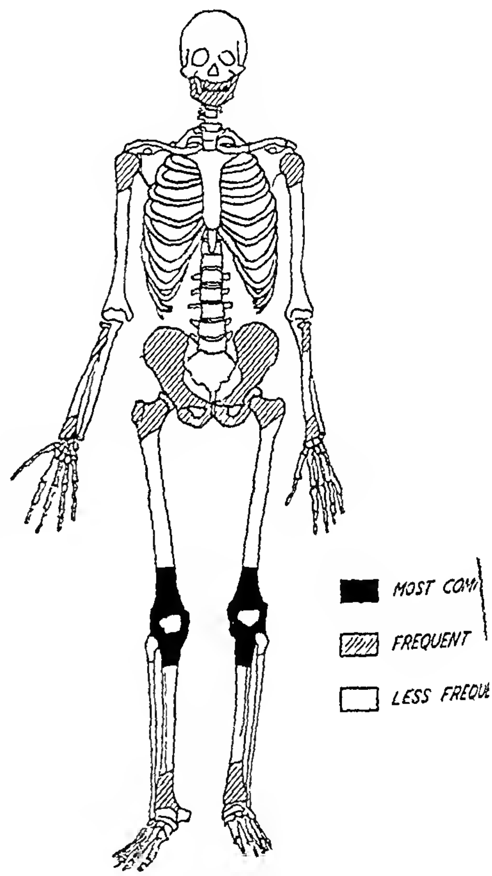

FIG 4

Diagram illustrating the sites of election of osteoclastoma of bone

Symptoms and Signs—There is often a history of injury and this was given in eleven of the twenty-five cases here reported, but little reliance should be placed on this because every patient, no matter what his ailment, has little difficulty in recalling antecedent injury Pain is the earliest manifestation It may first occur after injury which, though trivial, causes pathological fracture, and pathological fracture is often the first manifestation (Cases 2, 7, 15) Evidence of a tumour may not arise for several months It may then be possible to feel a rounded globular swelling with a sharp trough between it and the uninvolved shaft, in marked contrast with the more fusiform shape of an osteogenic sarcoma Tenderness is much less pronounced than in sarcoma When the tumour is large and the overlying bone is thin "egg-shell" crackling may be recognised A bruit is sometimes audible

Radiographic appearances—In typical cases the radiographic appearances are characteristic The epiphysial or juxta-epiphysial region is expanded by a destructive bone lesion in the centre of the bone, or less commonly on one side The expanded cystic area is bordered by a thin cortical shell, usually continuous but sometimes broken Articular cartilage resists invasion and the joint is seldom involved A thin area of sclerosed bone usually develops beneath the articular cartilage The margin of the tumour is demarcated clearly by a sharp semi-circular line which contrasts sharply with the irregular shaft extension

f osteogenic sarcoma, simple bone cysts and the cysts of osteitis fibrosa Bone trabeculae roject from the periphery into the translucent area, giving rise to a multilocular cystic ppearance In contrast with osteogenic sarcoma there remains no vestige of the old bone tructure Codman's reactive triangle and the sun-ray spicules of osteogenic sarcoma are never seen

Differential diagnosis—Biopsy may not be essential when radiographic appearances are typical, but it is sometimes difficult to differentiate giant-cell tumour from an osteolytic osteogenic sarcoma or from metastatic carcinoma with a silent primary lesion Histological examination is then imperative Biopsy is usually simple and safe, and punch biopsy is often sufficient Other bone conditions may also cause difficulty The radiographic appearances of one type of solitary plasmocytoma may closely resemble those of giant-cell tumour (Lumb and Prossor 1948, Cutler *et al* 1936, Gootnick 1945, Paul and Pohle 1940) Simple bone cysts generally occur in the metaphysis, and at an earlier age than benign giant-cell tumours, and as growth proceeds they become displaced down the shaft, there is no trabeculation and the cyst extends to some extent along the medulla, in contra-distinction to the sharply cut-off appearance of the giant-cell tumour Single chondromata occur in the centre of the shaft of the short bones, they are more spherical than giant-cell tumours and, unlike them, are surrounded by sclerosed bone, and they are often multiple, whereas the giant-cell tumour is always solitary In certain types of osteitis fibrosa the cysts are also multiple and there is osteoporosis of the compact bone with changes in the blood chemistry

Morbid anatomy and histological appearance—The tumours are soft, and red or red-brown in colour, resembling vascular granulation tissue in the midst of which there are often cysts filled with old blood, fat and bone debris New bone trabeculae traverse the tumour in many directions from the periphery Cancellous tissue is destroyed with attenuation and expansion of the cortex Articular cartilage is seldom penetrated The line of demarcation from the normal shaft of the bone is sharp and clearly defined The periosteum long remains intact and lays down a layer of new bone as it expands, occasionally it ruptures and permits extension of the tumour into surrounding tissues The histological appearances have been described clearly by Stewart (1922), Harvey *et al* (1940), Ewing (1940), and Willis (1948)

TREATMENT

Benign giant-cell tumours can be cured with greatest speed and certainty by excision, and there can be little doubt that this is the treatment of choice in such sites as the head of the fibula, lower end of the ulna, ribs, clavicle and patella Excision may also be indicated in other regions where loss of function can be repaired by reconstructive operations But surgical treatment is often made difficult by the proximity of these tumours to joints, and less radical surgical procedures such as curettage and filling of the cavity with bone chips have been used widely Meyerding (1945) reported forty cases treated in this way, with good results in all but two Nevertheless, curettage is followed by local recurrence in a high proportion of cases and Kolodny estimated the recurrence rate after curettage to be as high as 20 per cent Cases 1 to 5 in this series are examples Some surgeons have advocated swabbing the bone cavity with pure phenol, or Zenker's solution, but in general this has been abandoned because it may lead to sepsis, necrosis or secondary haemorrhage

After careful survey of the cases now reported, and others reported in the literature, it is the belief of this author that irradiation alone is the treatment to be preferred Recurrence after irradiation is unusual If it is carried out carefully the risk of haemorrhage, necrosis and sepsis is negligible Indeed, the only criticism that may be levelled against treatment by irradiation is the time required for healing and consolidation of the bone which may be as much as eighteen months

Treatment of recurrence after curettage—It is believed by some clinicians that recurrence after curettage does not respond well to irradiation Kolodny states "If curettage has been chosen and done, it should be done repeatedly if recurrence takes place, and if necessary amputation should be considered rather than a change to irradiation" Case 5 reported in this series is certainly not a good result But although irradiation after curettage may not give such gratifying results as irradiation alone there is probably no justification for so extreme a view Cases 1 to 5, all of which showed recurrences after curettage, are examples of good response On the other hand it should be recognised that post-operative irradiation may hinder new bone formation

The effect of irradiation—The energy absorbed from gamma rays of the teleradium unit, or from high voltage X-rays, can destroy the benign giant-cell tumour with progressive lessening of pain At the same time new bone is laid down, and, although it may be slow and take up to eighteen months, recalcification of translucent areas can be seen in the radiographs If irradiation is delivered too quickly, or if too great a dose is given, the tumour at first increases in size, the already thin shell of bone becomes still thinner The skin over the tumour becomes red, oedematous, hot and tender In general, the appearances are those of accelerated growth, or of malignant change in the tumour Attention has been drawn to these phenomena by many authorities (Brailsford 1943, Kolodny 19[illegible], Jansson 1944) They may be avoided if an appropriate dose of irradiation is given and if the rate of dosage is controlled carefully

Technique of irradiation—In this series both gamma rays from teleradium and high voltage X-rays were used The response was equally satisfactory Two opposing skin ports were employed and the dose delivered to the tumour in one course seldom exceeded 2500r X-rays were generated at 200 kv and 20 ma and filtered by 1 5 mm Cu+1 0 mm Al with a F S D of 50 cm In the first course a daily skin dose of 200r and a tumour dose of 90r were given the dose rate being 34r per minute The average duration of treatment was four weeks and the total tumour dose recommended is 2000r (except in the case of children where the tumour dose should not exceed 1200r) A second similar treatment is given after six months and, when necessary a third after eighteen months In cases treated by teleradium the Westminster Hospital 4-gram unit was employed with two opposing 63 64 sq cm skin ports On daily treatment of fifty minutes was given for twenty days each port being used on alternate days In this way 245r were delivered to the tumour every forty-eight hours Thus, in twenty days the tumour received 2450r

SUMMARY

1 Twenty-five cases of benign giant-cell tumour of bone, treated at Westminster Hospital, London, are reported

2 The diagnosis can often be made on clinical and radiographic grounds alone but biopsy is sometimes necessary and seldom, if ever, contra-indicated

3 Some cases may best be treated by excision, but in general irradiation is the treatment of choice

4 Details of treatment by irradiation are given

My thanks are due to the honorary staff of Westminster Hospital for permission to use their case records to Dr Peter Hansell of the Photographic Department and especially to Sir Stanford Cade and Dr F M Allchin for constant help and advice Part of this work has been done with the assistance of a grant to the Westminster Hospital from the British Empire Cancer Campaign

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Editor s Note—It is much regretted that owing to the limitations of space imposed upon us it has been necessary to exclude an unusually high proportion of the excellent illustrations submitted by this author

OSTEOCLASTOMA

A Study of Thirty-eight Cases

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In this paper thirty-eight cases of osteoclastoma are reviewed The patients were treated in the Middlesex Hospital between 1929 and 1948, and the Mount Vernon Hospital between 1942 and 1948 Six other patients, with tumours that were thought to be osteoclastomata, were also treated but they have been excluded because there is doubt as to the accuracy of the diagnosis In thirty-four of the thirty-eight cases now reported, there was histological confirmation, and in four cases the history, clinical features, radiographic appearances, and subsequent course, leave no doubt that the diagnosis was correct

Certain problems in the diagnosis, treatment, and clinical progress of these cases will be considered, particularly with regard to the development of malignant changes and metastases These problems have often been discussed and many diverse views have been expressed, analysis of this series, added to observations from other centres, may help to clarify disputed features in the life history of this tumour and give more definite indication the treatment that should be advised

Sex, age and site—There were fifteen males and twenty-three females The youngest patient was aged 8 years and the oldest 62 years Twenty of the thirty-eight cases occurred in the second or third decade The lower limb was involved in nineteen (50 per cent) and in just over half of them the tumour was situated near the knee joint femur, upper end 5, femur, lower end 4, tibia, upper end 5, tibia, lower end 3, fibula, upper end 1, patella, 1 The case in which the patella was involved has already been reported by Shorvon (1946) The upper limb was involved in six cases humerus, upper end 5, radius, lower end 1 Other tumours were in the vertebrae 5, sacrum 4, mandible 2, scapula 1, ischium 1

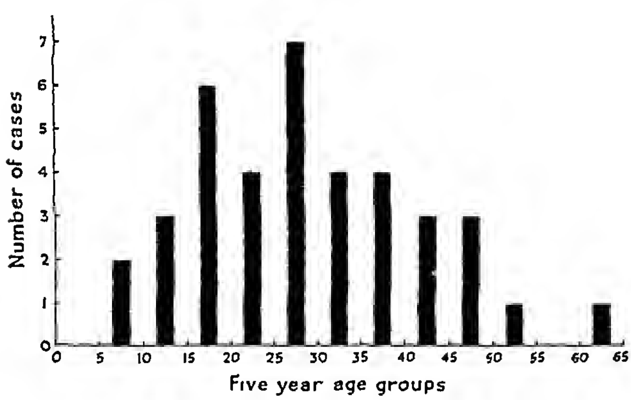

FIG 1

Age incidence of osteoclastoma of bone

Relationship of injury to osteoclastoma—It has often been said that there is close association between injury and the development of osteoclastoma, and for this reason a careful study was made of the clinical histories in an attempt to find the number of patients in whom the development of such a tumour was preceded by injury In seven, there was evidence of a blow causing pain and bruising and, after some months, pain and swelling at the same site which led to the diagnosis of osteoclastoma In four, there was a less definite history of a fall or strain some months before the onset of symptoms In the other twenty-seven patients there was no history of preceding injury although two were admitted to hospital after minor injuries which caused pathological fracture in a pre-existing but undiagnosed osteoclastoma

DIAGNOSIS BY RADIOGRAPHY AND BIOPSY

Much has been written as to the value and limitations of radiographic examination in diagnosis It has been said that the radiographic appearances may be so distinctive as to establish the diagnosis with certainty Brailsford (1943) stated that radiographic examination together with the history and clinical features, was sufficient and that biopsy was not only unnecessary but even misleading and harmful It is perhaps true that when the lesion is a

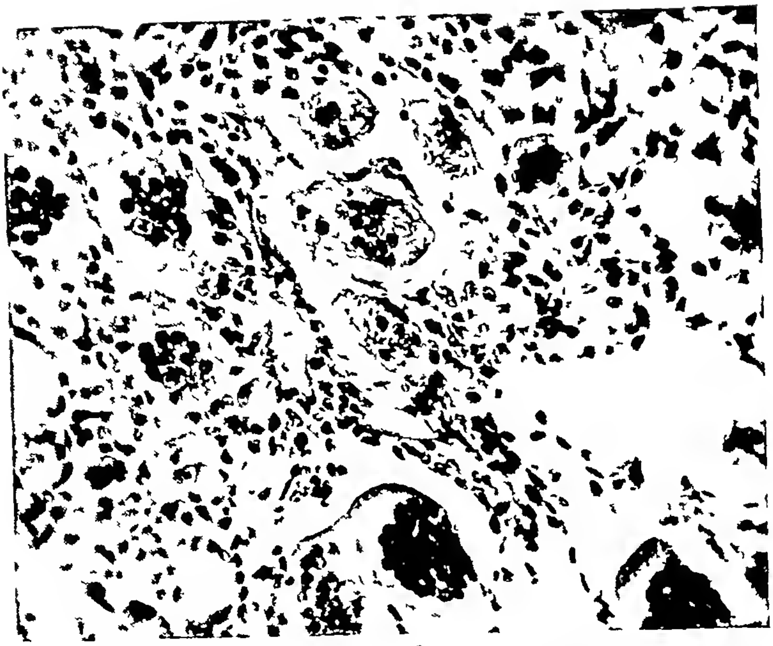

FIG 2
Histological appearances of typical osteoclastoma

FIG 3
Radiographic appearances of typical osteoclastoma

slowly growing and typically expanded and trabeculated tumour, situated at the end of a long bone such as that in Figure 3, radiological without histological examination may be sufficient but in cases such as those to which attention was first drawn by Kirklin and Moore (1932) with rapid growth, and no evidence of trabeculation or expansion of the cortex, and in which the tumour occupies an unusual site, radiographic examination alone is not sufficient to ensure accuracy of diagnosis

Cases with atypical radiographic appearances—In this series there were many cases with atypical radiographic appearances which gave rise to difficulty in interpretation Some of

these unusual features are illustrated in five cases, all of which proved to be osteoclastomata confirmed by histological examination

Figure 4 shows a small osteoclastoma in the neck of the left femur of a woman aged forty nine years A cyst had been removed from the right breast five months before she came to hospital complaining of severe pain in the left groin Clinical and radiographic examination suggested that the lesion might be a metastasis After biopsy, the diagnosis of osteoclastoma was established

FIG 4

Atypical osteoclastoma in the neck of the left femur in a woman from whom a cyst of the breast had been excised Radiographic appearances suggested that the lesion might be a metastasis

Figures 5 and 6 show an extensive tumour involving the upper end of the right femur, acetabulum and adjacent part of the ilium, superior ramus of the pubis, and part of the ischium The patient was a woman, aged twenty-six years, who gave a fifteen months' history of pain in the hip joint of gradual onset She had been treated by short wave diatherm and traction on the limb for fifty weeks! This lesion, which apparently started in the upper end of the femur, crossed the joint space to involve the bones of the pelvis—a behaviour that is contrary to generally accepted views as to the spread of osteoclastoma but which might be explained by the bridge of the ligamentum teres Such spread across a joint m also be seen in osteoclastomata of the sacrum which involve the ilium

Figures 7–9 show an osteoclastoma of the lower end of the left femur with pathologic fracture in a woman aged fifty-four years Raising of periosteum at the margin of the lesio gave an appearance that resembled that of osteogenic sarcoma Similar cases of osteoclastom associated with periosteal elevation were described by Hilton (1945)

Fig 5
Osteoclastoma of the head and neck of the femur involving also the ilium ischium and pubis

Fig 6
The same tumour as shown in Fig 5 two years after deep X-ray treatment

Fig 7

Fig 8

Fig 9

Osteoclastoma with pathological fracture into the knee joint periosteal reaction is seen (Fig 7) One month after deep X-ray treatment there was increased decalcification (Fig 8) Sixteen months after treatment the tumour is smaller the fracture is healed and there is sclerosis of the bone (Fig 9)

Fig 10

Osteoclastoma of the upper end of the tibia with involvement of the knee joint

Fig 11

Secondary deposit of adenocarcinoma of the rectum in the upper end of the tibia

Figure 10 shows an osteoclastoma in the proximal end of the right tibia of a man aged thirty-eight years There was a six months' history of gradual onset of pain The knee was swollen and tender, there was local increase of temperature, oedema of subcutaneous tissues and limitation of movement Radiographs showed that the tumour had broken through the articular cartilage as well as the cortex of the bone

Tumours resembling osteoclastoma—In addition to these patients, in whom the radiographic appearances of osteoclastomata were atypical, there were others with tumours which proved not to be osteoclastomata although the radiographic resemblances were very close Figure 11 shows a tumour of the upper end of the tibia in a patient aged sixty-four years In March 1948, after knocking his right leg, there was bruising and pain, the limb swelled and pain increased In July 1948 he was referred to Mount Vernon Hospital Drill biopsy showed that the lesion was an adenocarcinoma of the tibia, he was found to have an inoperable carcinoma of the rectum

FIG 12

Plasmocytoma of the pubis

Figure 12 shows a destructive, expanding bone lesion of the left pubis The patient gave a history of injury twelve months before the onset of symptoms Three weeks before the radiograph was taken he complained of pain in the left thigh and knee The history and radiographic findings were consistent with the diagnosis of osteoclastoma except that the site was unusual Drill biopsy showed that the lesion was a plasma cell myeloma and this was confirmed by sternal marrow puncture

HISTOLOGICAL EXAMINATION BY BIOPSY

In this series of thirty-eight cases, histological verification of the diagnosis was secured in thirty-four The other four patients were treated by X-ray therapy without biopsy because the clinical and radiographic features were typical Analysis shows that histological reports on the basis of biopsy were accurate and reliable The similarity of the histological picture

FIG 13

Osteoclastoma of the fifth lumbar vertebra causing lateral distortion of the fourth lumbar vertebra

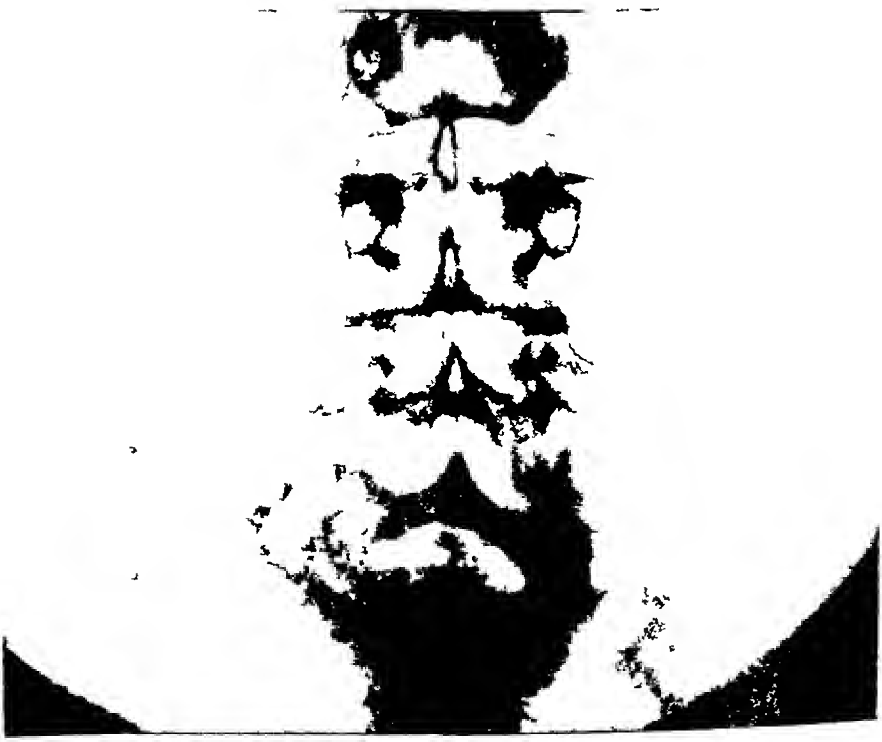

FIG 14

Same case as in Fig 13 four months after deep X-ray treatment

of osteoclastoma with that of osteitis fibrosa is unlikely to give rise to erroneous diagnosis if the clinical as well as the radiographic features are taken into consideration

Drill biopsy was carried out only in a small number of cases because it was thought that it might not be reliable and a representative part of tumour might not be obtained In fact, however, reliable results were secured in those cases in which it was used Incisional biopsy was performed in most cases In some, this consisted of the removal of a small piece of tissue from the margin of the tumour In others a large wedge of tumour tissue was removed It has been found however, that all the information obtainable from a large piece of tumour tissue can be obtained equally well from a small piece, and the first method is free from some of the disadvantages of the second When wide removal was made there were some cases of breaking down of the wound, infection of the cavity and the development of a sinus

TREATMENT AND RESULTS

Surgical treatment—Nineteen patients were treated surgically, nine without post-operative X-ray treatment and ten with Amputation was performed in two of these one with osteoclastoma of the lower end of the femur is well eighteen years after amputation through the thigh, the other died three years after interscapulo-humeral amputation with metastases in the lungs

Two patients were treated by local excision One, previously reported by Shorvon (1946), is well two years after excision of the patella The other had excision of a tumour of the lower end of the radius with replacement by the upper end of the fibula and arthrodesis of the wrist joint, there was recurrence after four years which was treated by X-ray therapy, three years later, the patient is well

Five patients were treated by curettage Three are still well fourteen, nine, and eight years after operation respectively One, who had a tumour of the upper end of the humerus, developed a recurrence which was treated by irradiation After this he worked for six years as a labourer, then there was further recurrence The limb was amputated because it was thought that malignant change had occurred Three years after amputation he is well One patient developed recurrence of an osteoclastoma of the upper end of the humerus eighteen months after curettage and was treated by X-ray therapy, he died two years later from metastases in the lungs

Surgical treatment with post-operative X-ray treatment—Ten patients were treated surgically with post-operative radiotherapy In one, excision of a tumour of the upper end of the fibula treated after operation by X-rays, is well fourteen years later The others had incomplete removal or curettage with post-operative radiation Three have been lost from follow-up, one and two years after treatment, when they were apparently well Four are still well five to ten years after treatment Of the other two patients, one, with a tumour of the lower end of the femur, developed recurrence with extension into the knee joint, it was excised and the patient died from post-operative pulmonary embolism In the other there was recurrence of a tumour of the upper end of the tibia, malignant change was diagnosed, the limb was amputated through the thigh but the patient died

Treatment by radiotherapy alone—Nineteen patients were treated by radiotherapy alone three were treated by interstitial radium or radon, sixteen were treated by X-ray therapy, with preliminary biopsy in twelve One, with an osteoclastoma of the upper end of the femur, treated by incomplete removal and insertion of radium tubes, is free from recurrence eighteen years later but still has a discharging sinus One patient with a tumour of the scapula, treated by radium needle implantation with surface radium application, is free from recurrence seventeen years after treatment but has marked scarring and telangiectasis of the skin One

FIG 15
Case 1 Osteoclastoma of the sacrum, invading the ilium, previously treated by the insertion of radon seeds but with an abscess and sinus formation

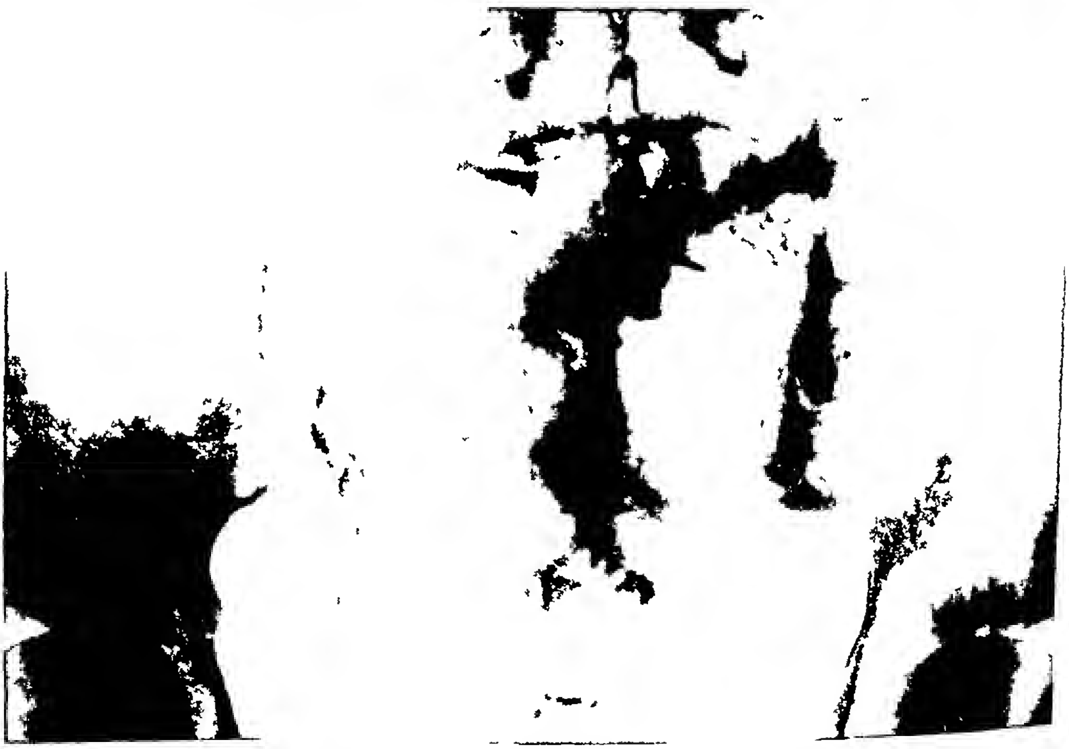

FIG 16
Case 1 The abscess was drained and fifty-eight radon seeds were removed Treatment was given by a one gramme teleradium unit More radon seeds were discharged until only three remained The wound healed except for one sinus The patient now plays badminton enjoys all recreations and leads a normal life

patient, who had been treated by the insertion of radon seeds to an osteoclastoma of the sacrum had a discharging sinus and an expanding tumour, after removal of the seeds, teleradium was given, the patient is still well fifteen years later but he has a discharging sinus

Of the sixteen patients treated by X-rays one has been lost from follow-up Two have been treated recently and the results cannot yet be assessed One died of bronchitis and heart failure two years after treatment for a large tumour with pathological fracture of the lower end of the femur, apart from a stiff knee joint which prevented him from carrying on his occupation as a cab driver he had no symptoms referable to the lesion One patient with an osteoclastoma of the lower end of the femur confirmed by biopsy had X-ray treatment, after initial improvement the tumour fungated through the skin, a diagnosis of local malignant change was made and the limb was amputated three months ago Eleven patients remain well and free from recurrence for periods of from one to ten years The period of observation since treatment is not long enough in all of them to be sure that they will remain free from recurrence, but in every case there is evidence of sclerosis of the lesion and no sign of activity

Technique of X-ray therapy of osteoclastoma—The technique of X-ray therapy has been fairly uniform throughout the last twelve years X-rays generated at 200 or 220 kilovolts, with half value layer of 1 1 or 2 1 mm copper respectively, were used The dose given to the tumour in a single course, lasting from twenty to thirty days, varied between 2000 and 3000 roentgens A second course of treatment was usually given about three months after the initial course The typical reaction after such treatment, which has often been described, is a preliminary stage of increased decalcification with apparent extension of the tumour After about two months, recalcification begins and increases The final result from X-ray therapy, which may not be achieved for many months, is diminution in size of the tumour with replacement of the thinned cortex by dense sclerotic bone, trabeculae become thick and dense but the bone does not regenerate entirely and cystic spaces remain

Case Report—A girl aged fifteen years gave a four months' history of pain in the right leg and lumbar region Radiographs showed a trabeculated tumour involving the right side of the fifth lumbar vertebra, extending outwards above the right sacro-iliac joint, with lateral dislocation of the fourth lumbar vertebra (Figs 13 and 14) Biopsy showed that the tumour was an osteoclastoma A single course of deep X-ray therapy was given, the tumour dose was 2000r After one month pain was relieved, and after the second month there was complete freedom from symptoms and there were no abnormal physical signs Radiographs four months later showed reduction in the size of the tumour, sclerosis of bone, and accurate apposition between the fourth and fifth lumbar vertebrae The patient remains well eighteen months after treatment

Seven of the cases described warrant more detailed consideration In two, there were unusual clinical and radiological features, and in five, malignant changes supervened

TWO CASES WITH UNUSUAL FEATURES

Case 1 *Female, aged* 28 *years*—In March 1933 an osteoclastoma of the sacrum was partly excised and treated by X-rays Pain continued and the tumour increased in size In October 1933, radon seeds were inserted In January 1934 an abscess developed She was admitted to the Middlesex Hospital in February 1934 Radiographs showed masses of radon seeds in a cystic area in the left side of the sacrum (Fig 15) There was extension of the growth into the left ilium On March 7, 1934, the cavity was opened by the late E Pearce Gould, necrotic material, with fifty-eight radon seeds, was removed In April 1934, treatment was given by one gramme teleradium unit to the whole tumour During the next year the margins of the tumour became sclerosed The sinus persisted More radon seeds were

extruded until only three remained The pain subsided and by June 1935 the patient was able to walk without a stick In 1936 she played badminton From 1941 to 1945 she worked in the Civil Nursing Service There was still a sinus which she dressed regularly In August 1945 copious leakage from the sinus was reported and the patient complained of persistent headache, more severe when standing erect The discharge reduced Fehling's solution and was found to be cerebro-spinal fluid The wound was cleaned and packed with fibrin foam Pyrexia and severe headache persisted, with pain in the back and retention of urine A cell count of the cerebro-spinal fluid showed 630 cells per cubic millimetre, 83 per cent polymorphonuclear cells, 12 per cent lymphocytes, 5 per cent erythrocytes Penicillin and sulphathiazole were given, the symptoms of meningitis abated within a week The wound became dry and she was discharged from hospital on October 3, 1945 Since that time she has had no exacerbation of symptoms There is still a sinus but she is able to lead a normal life Figure 16 shows the condition in August 1947

FIG 17

Case 2 Osteoclastoma of the lower end of the radius treated by excision and replacement with graft of fibula The graft was invaded by a locally recurrent osteoclastoma

This case illustrates the disadvantages of treatment of osteoclastoma by interstitial irradiation and particularly by the insertion of radon seeds There is risk of infection with persistent discharging sinuses Moreover, it is almost impossible to ensure adequate irradiation of the whole lesion

Case 2 Female, aged 38 *years*—In 1942 an osteoclastoma of the lower end of the right radius was treated by the late Mr Rowley Bristow by excision of the lower end of the radius replacement by part of the fibula, and arthrodesis of the wrist joint In January 1946, a tumour appeared on the volar surface of the limb, proximal to the wrist, and biopsy showed that it was a recurrent osteoclastoma After X-ray therapy the swelling diminished There is still a hard lump but there are no symptoms and the patient is in good health This case illustrates invasion of a bone graft by recurrent tumour (Fig 17)

CASES IN WHICH MALIGNANT CHANGES OCCURRED

Case 3 Male, aged 31 *years*—In February 1932 this patient was admitted to the Middlesex Hospital complaining of pain and swelling of the ankle joints, knee joints and right wrist joint The left upper limb had been amputated three years previously for what was said to be a sarcoma of the humerus No histological details were available He was found to have marked hypertrophic osteoarthropathy involving nearly all the long bones There was a tumour in the left lung Lobectomy, performed by Mr Vaughan Hudson, gave immediate relief of pain and improvement in the swelling of joints, but the patient died in September 1932 from lung metastases The histological picture shows an atypical osteoclastoma (Fig 18) There are giant cells of the osteoclast type, and a cellular stroma which differs from the normal appearance in that the cells are less regular in size and are spheroidal rather than spindle shaped

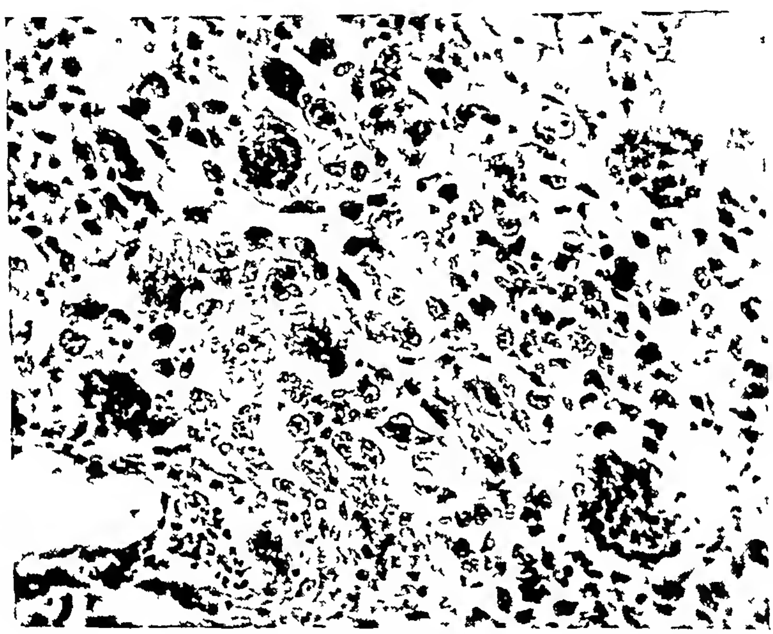

FIG 18
Case 3 Metastases in lung (×250)

Case 4 Male, aged 33 *years*—For one year complained of increasing pain in the left shoulder extending down the arm A diagnosis of osteoclastoma of the upper end of the left humerus was made and after curettage the pain was relieved In July 1941 pain recurred and radiographic examination showed extension of the lesion Treatment by X-rays was given in July 1941 and in November 1941 Pain was then relieved and the bone became sclerosed After one year there was recurrence of pain In June 1943 the patient was found to have metastases in the lung, and he died in August 1943 Autopsy showed extensive pulmonary metastases of sarcoma

Case 5 Male, aged 38 *years*—In 1935, after minor injury, sustained a pathological fracture through an osteoclastoma in the head of the left humerus The lesion was treated by curettage and bone grafting In August 1937 and December 1937 he was given X-ray treatment because of recurrence After this he remained well and was able to work as a labourer until July 1944 when pain recurred He was given a further course of X-ray treatment at another hospital In June 1946 the limb was amputated because it was thought that the lesion had become malignant The diagnosis of sarcoma was confirmed histologically after amputation In January 1949 there was no sign of recurrence

FIG. 19

FIG. 20

Case 7. Radiographic appearances of an osteoclastoma of the tibia in February 1948 shortly after X-ray therapy (Fig. 19) and in July 1948 when there was ulceration over the tumour from the pressure of a splint (Fig. 20).

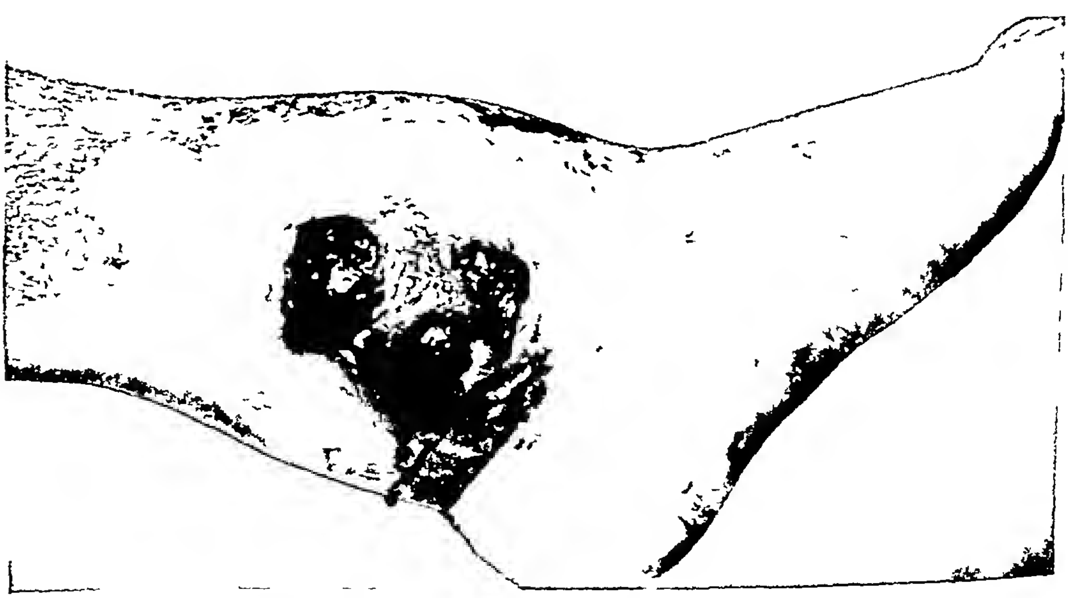

FIG. 21

Case 7. Clinical appearance of the limb at the time of amputation.

Case 6 Female, aged 18 years—Pain in the left knee began in June 1939 and gradually became worse The diagnosis of osteoclastoma was established by radiographic examination and biopsy Curettage was performed in April 1940, the cavity being filled with bone chips After operation, there was a discharging sinus X-ray therapy in July and September 1940 gave rise to considerable improvement, the sinus became smaller In June 1941 the condition was thought to have undergone malignant change and the limb was amputated The patient died in August 1943 The difficulties of follow-up in time of war have made it impossible to secure further pathological details

Case 7 Female, aged 47 years—Three years previously this patient fell and injured her left ankle, it was oedematous for some time In June 1947 she complained of aching pain and swelling of the left ankle Biopsy was performed on December 15, 1947, a large piece of

FIG 22

Case 7 Appearances of the tumour after amputation of the limb

tissue was removed with a spoon and reported as osteoclastoma Double below-knee irons were fitted She was given X-ray therapy in January 1948 to a total tumour dose of 2100r, and in May 1948 to a total tumour dose of 2200r Radiographic examination on July 19, showed increased sclerosis but at that time it was noted that there was superficial ulceration over the medial malleolus, in the region of the biopsy scar, where the splint had been pressing This did not heal and a tumour mass fungated The limb was amputated below the knee by Mr P H Newman on November 25, 1948 Figures 19 and 20 show the radiographic appearances of this tumour in February and July 1948 Figure 21 shows the clinical appearance at the time of amputation, and Figure 22 is an illustration of the specimen

It is unfortunate that more detailed documentation is not available in all the five cases in which malignant changes have been presumed In Case 3 the primary tumour had been

treated in another institution but histological findings support the evidence that metastases from an osteoclastoma can occur with little alteration in the histological picture from that of the primary lesion In 1905 Gordon Taylor reported a similar case with a primary tumour of the femur and metastases in the lungs, and concluded "the case is therefore of value in two ways firstly, it proves clearly that giant-cell sarcomata do form metastases, and secondly, that giant-cells are reproduced in the secondary deposits" The case reported by Finch and Gleave (1926), with their review of several others, has also shown quite definitely that this may occur In Case 4 there was alteration in the character of the tumour and the metastases were typical of sarcoma In Cases 5 and 6 there was a definite histological report of malignant transformation but the micro-sections were not examined personally In Case 7 there is clear evidence of local malignancy but whether or not this will lead to the development of metastases must, for the moment, remain problematical

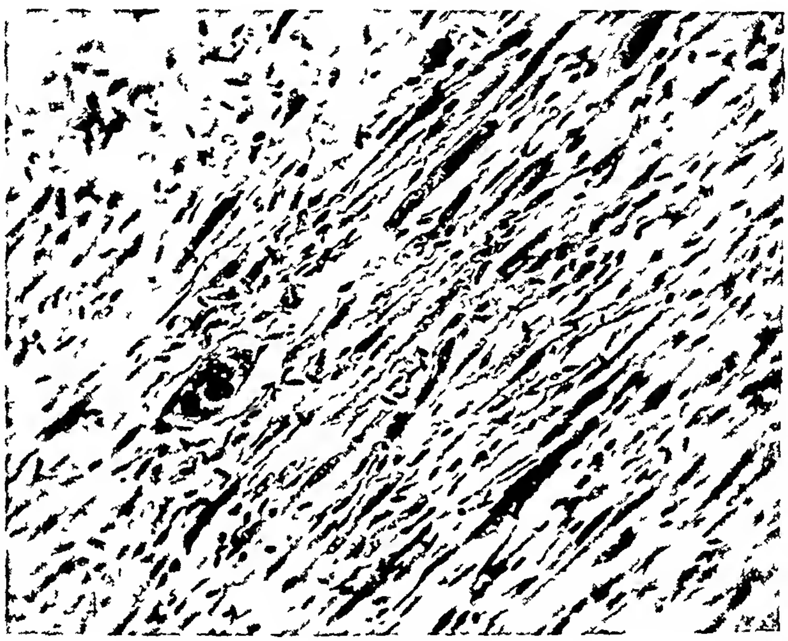

FIG 23

Case 7 Osteoclastoma of the tibia with local malignant change

All five tumours in which it is presumed that malignant change has occurred were in the long bones Three were in the humerus This is a high proportion, considering that in only five was the humerus involved out of the total number of thirty-eight cases reported An attempt has been made to examine the conditions or methods of treatment that might have predisposed to the development of malignant change It appears that in Case 3 the only treatment was amputation In Cases 4, 5, and 6, treatment was by curettage followed by X-ray treatment—given in Cases 4 and 5 by reason of recurrence and in Case 6 as a post-operative measure In Case 7, after wide biopsy and subsequent X-ray therapy, there was the additional factor of trauma from the rubbing of the double leg iron on the site of the biopsy scar

CONCLUSIONS

1 In this series of thirty-eight cases of osteoclastoma, twenty-five occurred at the end of a long bone Nineteen were in the lower limb and half of these were near the knee joint, six were in the upper limb, of the remainder, nine occurred in the vertebrae or the sacrum

2 More cases occurred in females than males, the ratio being twenty-three females to fifteen males Just over half the cases occurred in the second and third decades

3 In seven there was a definite history of injury preceding symptoms by several months

4 It is often difficult to arrive at a diagnosis on clinical and radiographic findings alone Histological information is usually necessary before a certain diagnosis can be made A limited biopsy is safe and reliable

5 Malignant change with the development of metastases occurs in a small proportion of cases, regardless of the particular treatment that has been employed This is illustrated in Case 3 of this series, in the case reported by Gordon Taylor, and in the case reported by Finch and Gleave

6 The methods of treatment used in the patients here reported included curettage or local excision, with or without radiation, and radiation alone

7 The patients treated by curettage or excision were dealt with during an earlier period than those treated by irradiation alone, and an exact comparison of results is not possible The follow-up of patients treated by radiotherapy alone is too short to exclude the possibility of recurrence, but the immediate results appear to show definite improvement upon those of surgical treatment

8 In this limited series it is to be noted that malignant change occurred in a higher proportion of cases treated by curettage and radiotherapy than in those treated by radiotherapy alone

9 It appears that, in the treatment of osteoclastoma of bone, radiotherapy alone is the treatment of choice

The authors wish to acknowledge their indebtedness to their colleagues for permission to include cases admitted under their care They are particularly indebted to Professor R W Scarff and Dr A C Thackray of the Bland Sutton Institute of Pathology for their help

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TREATMENT OF OSTEOCLASTOMA BY RADIATION

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Osteoclastomata arise in the metaphyses of long bones, but when there is fusion of epiphyses the tumours may extend as far as the articular cartilage They occur also in the bones of the face, skull and spine In the skull, the tumour follows the distribution of cartilaginous centres of ossification and this has been held to support the view that it is attributable to "persisting developmental processes occurring in pre-cartilaginous and pre-osseous connective tissues" (Geschickter and Copeland 1931) Willis (1948) considered that osteoclasts, osteoblasts, fibroblasts and chondroblasts were intermutable and that enzyme changes probably determined the function, and therefore the histological appearances, of the cells Geschickter and Copeland said that "in osteoclastoma and osteitis fibrosa giant cells can be seen on the outside of new blood vessels and vascular spaces, showing that the giant cells in these lesions retain the same histological function as the osteoclasts seen in human and other mammalian embryos" They suggested that there was a growth of blood vessels with osteoclasts from the marrow towards part of the cortex, the blood supply of which had suffered in some cases from trauma, and that an osteoclastoma might result from persistence of the excess of of osteoclasts They considered that osteoclastomata arose only in regions where bone was developed in pre-existing cartilage, and this view accords with experience Osteoclastomata are quite distinct from solitary bone cysts, and from the cystic lesions associated with hyperparathyroidism, but they are probably related to the giant-cell epulis and possibly to giant-cell tumours of tendons

Diagnosis—Before treatment is undertaken the diagnosis of osteoclastoma should be established beyond reasonable doubt Difficulties may arise in distinguishing the tumour from bone sarcoma, malignant myeloma and metastatic carcinoma, and from such benign lesions as simple bone cysts, hyperparathyroid fibrocystic disease, chondromata and chronic bone abscesses Investigations that may be helpful in the differential diagnosis include the blood count, Wassermann reaction, radiography of lung fields, urine analysis and blood chemistry The serum alkaline phosphatase is raised in osteogenic sarcoma, osteoplastic metastases, hyperparathyroidism and osteitis deformans, it may be raised slightly in osteoclastoma, endothelioma of bone and plasma cell tumour The serum inorganic phosphate is low in hyperparathyroidism and may be high with osteolytic metastases and plasma cell myeloma, it is normal in other neoplastic conditions including osteoclastoma The serum calcium is high in hyperparathyroidism and may be high with osteolytic metastases and plasma cell myeloma, being normal in other neoplastic conditions including osteoclastoma (Greenstein 1947)

Biopsy—Biopsy is so valuable a method of diagnosis that it should always be used when the nature of a bone tumour is doubtful The arguments advanced against biopsy appear to have little validity It was said by Bloodgood (1931) that, of sixty-five patients with bone tumours surviving five years, no less than half had been submitted to biopsy before operation, which suggests that the chances of survival were not prejudiced thereby Moreover, there is evidence that radiation before or after biopsy has protective value This author has made much use of drill biopsy, which often provides unequivocal results, and has certain advantages over open biopsy in that complications are less frequent and admission to hospital is unnecessary

Differentiation of osteoclastoma from bone cysts—This differentiation has often given rise to confusion, and yet it is important because bone cysts represent healed osteoclastic lesions and do not require treatment *Age incidence*—The age incidence of bone cysts is earlier than that of osteoclastomata although of course there is much overlap, a b

cyst has been reported in a patient of sixty years and an osteoclastoma in a child of seven years *Site*—Osteoclastomata usually occur at the metaphysial ends of the diaphyses, most commonly in the tibia, femur or humerus The cyst which results from healing of the osteoclastic process tends to be left behind in the shaft as epiphysial growth proceeds *Histology*—The histological appearances are distinctive A bone cyst is lined with fibrous tissue which may contain areas of old haemorrhage and spicules of newly formed bone, surrounded by osteoblasts, probably formed from fibroblasts which are laying down intercellular substance, the giant cells that are typical of osteoclastoma may be present around the new vessels in small numbers On the other hand the histology of an osteoclastoma is characterised by uniform distribution of large giant cells containing from twenty to two hundred nuclei embedded in a mass of small round or spindle cells which may show mitotic figures Geschickter and Copeland stated that in true osteoclastomata " round cells outnumber the spindle cells in every instance," and that spindle-cell formation was indicative of a healing form of giant-cell tumour Willis on the other hand did not mention round cells *Radiographic appearances*—A bone cyst is seen typically as a central area of translucency in the shaft of the bone near the metaphysis, situated progressively further from the end of the bone as epiphysial growth continues This is an important differential point The appearances in osteoclastoma are those of a destructive lesion, asymmetrically or centrally placed, with an expanded bone shell, usually in the end of a long bone There is seldom periosteal reaction and the epiphysis is usually united The cortex may be perforated Successful treatment of an osteoclastoma by surgery or radiation may result in normal growth with a residual cyst left behind in the shaft of the bone

PRINCIPLES OF TREATMENT

The aims of treatment, whether by curettage, resection, amputation or radiation, are to relieve symptoms and restore normal structure and function of the bone *Curettage* may be unsatisfactory by reason of persisting mechanical weakness and the danger of local recurrence necessitating further operation *Resection* is justified only when the site of the lesion permits complete removal without impairment of function, as for example in the upper end of the radius, the lower end of the ulna, and the fibula *Amputation* is seldom justified because the lesion is essentially local and satisfactory results can be obtained by conservative treatment *Radiation* is capable of achieving results no less satisfactory than those of surgical operation and without the danger of weakening the bone by removal of intact cortex in order to expose the tumour

RADIATION TREATMENT OF OSTEOCLASTOMA

The radiation used in most cases in the series now reported was by X-rays, a total of 3000 roentgens being given on alternate days over a period of three weeks The object was to treat only the lesion itself, the tumour is so circumscribed that there is no need to treat a large area of adjacent bone as in the case of malignant tumours Greater doses have sometimes been used but they were probably unnecessary Indeed, many successful results have been reported with even shorter exposures, and it is proposed to treat a series of cases with a dosage of no more than 1500r In four patients it was thought advisable to repeat the course of treatment because there was persistence of symptoms or because there was no radiographic evidence of consolidation and, from the rapid effect of such a second course, it appears that this is justified in occasional cases A few patients have been treated by the implantation of radium needles into the tumour, and in one early case by the insertion of radium into the cavity after curettage It should be recognised, however, that radium needles produce no better results than X-ray treatment and they cause much more trouble, not only to the surgeon and radiotherapist but also to the patient The use of radium after curettage may cause bone necrosis and increases the risk of other complications

The mode of action of irradiation on osteoclastomata is unknown, but from ou knowledge of the effects of irradiation on enzymes, the sensitivity of osteoclastomata t small doses, and the relationship of osteoclasts and their precursors to osteogenic tissue, i is reasonable to suppose that irradiation gives rise to enzyme modifications which alter th form of activity of the cells so that a predominantly osteolytic process is replaced by a proce of new bone formation

Results of radiation treatment of patients reported in this series—The results treatment in this series of twenty-six cases are summarised in Table I In every case t response to irradiation was good Brief summaries of individual case histories are appende In the Table, under the heading of "final diagnosis" which is based upon all eviden including that of response to treatment, the possibility has been considered that tumour with giant cells may have been healing lesions Thus, four of the twenty-six cases wer classified finally as healing lesions at the time of treatment, though in each of them th history was short Five of the twenty-six cases have been excluded from the report becaus there was some doubt as to the diagnosis All others were true osteoclastomata, except Case 11 which was a malignant osteoclastoma

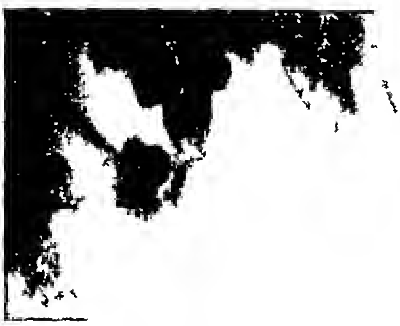

FIG 1

FIG 2

Case 1 Female aged 16 years Osteoclastoma of the mandible confirmed by biopsy (Fig 1) Radiograph three years after X-ray treatment is seen in Fig 2

FIG 3

FIG 4

Case 3 Female aged 11 years Osteoclastoma of the calcaneus spindle-celled variant confirmed by biopsy by Professor Turnbull before treatment (Fig 3) and two years after X-ray treatment (Fig 4)

Results of treatment by radiation alone reported in the literature—Lacharite (192 reported fourteen cases, traced for periods of three to ten years after treatment, seven we cured, in seven there was recurrence Herendeen (1931) followed up five patients for five t ten years after treatment and all were cured Soeur (1931) traced six patients for three to te years and all were cured Hummell (1932) reported twelve cases, ten were cured by radiatio treatment and two became malignant Peirce (1932) treated five patients and all were cure

Pfahler and Parry (1932) reported twenty-six patients of which twenty-four were cured by radiation alone Gunsett *et al* (1934) treated two patients (4000r and 5000r) and both are well Stevens (1935) treated one patient with a dosage of 1500r in two months and he is well Freund and Meffert (1937) reported that two of five patients were cured by radiation and one was "improved", of twelve patients treated surgically only two were "improved" Doub *et al* (1938) reported four cases, two of which were cured by radiation and two proved to be malignant Leucutia *et al* (1941) reported "good results" in eighteen patients treated with 300-1000r repeated two monthly Edeiken (1940) reported one patient cured with 1500r and a further 2000r after two months

CASE REPORTS

Case 1 E B, female, aged 16 years—Osteoclastoma of the mandible (Figs 1 and 2) November 1944 tumour of left side of lower jaw eight months duration December 1944 referred with swelling 5×3 cm in the region of the lower left first molar Cortex intact over external surface but eroded at the inner surface of the mandible *Drill biopsy*—osteoclastoma X-ray treatment 3500r fourteen treatments in twenty-one days no change, no pain April 1946, X-ray treatment 3000r , ten treatments in twenty one days December 1947 tumour 3 5×3 cm May 1948 no further change *Comment*—An osteoclastoma developing in cartilaginous bone

Case 2 C W, female, aged 19 years—Recurrent osteoclastoma of the humerus Referred December 1944 having had curettage of a tumour in the head and neck of the left humerus in December 1942 *Histology*—osteoclastoma No change in size of the lesion as shown by radiographs until June 1944 when there was much increase in size *On examination*—tender swelling of the upper end of the left humerus with loss of power December 1945 X-ray treatment 3000r ten treatments in twenty-two days tenderness relieved after seven weeks gradual recalcification well after three years *Comment*—Successful treatment by radiation of recurrence after curettage

Case 3 S L, female, aged 11 years—Fibro-osteoclastoma of the calcaneus (Figs 3 and 4) July 1945, referred for pain in the left heel of three weeks' duration *On examination*—left os calcis thickened not tender radiographs showed destructive lesion of the os calcis with expansion Clinical diagnosis—osteoclastoma *Drill biopsy*—osteoclastoma with few osteoclasts composed mostly of spindle cells and collagen fibres July 1945 radiation treatment 3000r ten treatments in twenty-three days symptoms relieved only after three months Remains well but with some wasting of the left calf Radiographs show complete consolidation *Comment*—The histology suggests a lesion healing at the time of the biopsy, before treatment

Case 4 M E, female, aged 14 years—October 1945, referred with pain in the left shoulder after a fall one year before *On examination*—upper end of the left humerus swollen tender, and slightly hot abduction of the limb impossible radiographs showed osteolytic lesion of the epiphysis of the great tuberosity *Drill biopsy*—yellow material osteoclastoma giant cells not numerous November 1945 radiation treatment 3000r ten treatments in twenty-one days pain and disability persisted February 1946 treatment repeated 3000r ten treatments in twenty-one days pain relieved after six weeks May 1948 well no pain telangiectasis of treated skin still marked limitation of movement, radiographs show consolidation but still an area of translucency *Comment*—In spite of the possible cystic nature of the tumour the patient did not lose her pain until after the second course of radiation

Case 5 D C, male, aged 13 years—November 1945 swelling of the mandible of three weeks duration *On examination*—fleshy ulcerated tumour near the premolar teeth *Drill biopsy*—osteoclastoma December 1945 radiation treatment 3000r thirteen treatments in twenty-eight days rapidly improved well since *Comment*—A giant cell epulis

Case 6 K St P, male, aged 14 years—Osteoclastoma of the head and neck of the fibula November 1945 pain in the upper end of the right fibula of five weeks duration after injury *Radiographs* showed pathological fracture November 1945 excision of the whole tumour and upper shaft of the fibula December 1945 radiation treatment 2800r ten treatments in twenty-four days July 1947 well August 1948 normal except for slight weakness of leg and aching after exercise *Comment*—Would he have been better without excision? *

Case 7 M F, male, aged 11 years—Osteoclastoma of the maxilla February 1947 six months increasing painless swelling right side of face *On examination*—thickening of the maxilla with bone expansion of antral wall and destruction of the right half of the hard palate which showed a soft cystic

* Editor's note—On the other hand would he have been better without radiation? But perhaps I am prejudiced It happens that I excised it

swelling March 1947 right antrostomy, friable tissue *Histology*—osteoclastoma April 1947 radium insertion, 4500r in nine days six differentially loaded needles Drill biopsy of fluctuant swelling—osteoclastoma March 1948 swelling smaller, no symptoms *Comment*—Radium used in this case to localise the dose and thus minimise damage to unerupted teeth

Case 8 J T, female, aged 22 years—Osteoclastoma of the femur (Figs 5 and 6) June 1944 pain in the right knee with loss of function *Radiographs* showed osteoclastoma lower end of femur Radiation treatment 2000r eight treatments in twenty-four days June 1945, recurrence of pain after dancing July 1945 radiation treatment 3000r ten treatments in twenty-three days symptoms relieved after six weeks Remains well, slight limitation of extension of knee *Comment*—Typical osteoclastoma

FIG 5

FIG 6

Case 8 Female aged 22 years Osteoclastoma of lower end of femur before treatment (Fig 5) and three years after two courses of radiation treatment (Fig 6)

Case 9 S E, female, aged 22 years—Osteoclastoma of the radius (Figs 15 and 16) January 1944 pain and swelling left wrist pathological fracture *Open biopsy and curettage*—osteoclastoma confirmed February 1944 radiation treatment ten treatments in twenty-two days plaster immobilisation May 1945 telangiectasis ulnar deviation and dorsal displacement of wrist July 1948 no change *Comment*—Marked deformity in spite of attempts to maintain position by plaster

Case 10 E L, female, aged 28 years—Osteoclastoma of the maxilla January 1946, swelling left maxilla, increasing in size operation one year previously cavity opened and lining removed *Histological examination*—osteoclastoma *On examination*—swelling of the left maxilla 4 5×2 cm "crackling" on pressure "Antrostomy" opening in the swelling February 1946 radiation treatment 3000r ten treatments in twenty-two days marked erythema occurred August 1946 swelling reduced to 3×2 cm November 1947, no swelling free from symptoms

Case 11 S K, female, aged 29 years—Malignant osteoclastoma of the tibia (Figs 7-10) May 1945, increasing intermittent pain left knee sprain two years previously *On examination*—swelling of the upper end of the tibia slight "crackling" *Drill biopsy*, 1945—osteoclastoma May 1945 radiation treatment 3000r ten treatments in twenty-three days symptoms relieved until January 1946 when radiographs showed further destruction outside the previous sclerotic zone *Drill biopsy*, 1946—malignant osteoclastoma February 1946 radiation treatment 3300r, twelve treatments in twenty six days March 1946 slight improvement May 1946 radiographs showed deterioration and metastases in the chest July 1946 amputation for the relief of pain November 1946 died Metastases in the spine and lungs *Comment*—Probably a malignant case from the start Rapidly fatal and very painful At first behaved like an osteoclastoma in its response to radiation (See "Malignant Osteoclastoma" by Prof D Russell this number of the Journal)

FIG 7

FIG 8

FIG 9

FIG 10

Case 11 Female aged 29 years Malignant osteoclastoma of the tibia (see article this number of the Journal by Professor D Russell) The radiograph in May 1945 is shown in Fig 7 At that time drill biopsy suggested that the tumour was a typical osteoclastoma but is the radiographic evidence of calcification of the tumour a sign of its atypical character? Two months later after irradiation there is increased porosis (Fig 8) Five months after treatment the lesion appears to be healing (Fig 9) Twelve months after treatment there was extensive bone destruction (Fig 10) and drill biopsy at that time showed evidence of a malignant osteoclastoma The patient died two months later with metastases in the lungs and spine

FIG 11

FIG 12

FIG 13

FIG 14

Case 14 Male, aged 42 years Osteoclastoma of the tibia, confirmed by biopsy (Fig 11) After irradiation there was initial increase in the size of the tumour (Fig 12) Immobilisation in traction in a Thomas splint and later in plaster was necessary Six months later there was radiographic evidence of recalcification (Fig 13) After two years there was marked increase in the calcification the lesion is healing and the patient is well and walking unaided (Fig 14)

Case 12 G C, female, aged 34 years—Osteoclastoma of the mandible Swelling of the right lower jaw of five months duration October 1945 operation—excision of central osteoclastoma from lower jaw *Histology*—osteoclastoma with moderate number of giant cells, much delicate fibrous tissue and new formation of woven bone No evidence of malignancy October 1945, radiation treatment 4000r ten treatments in twenty-one days, erythema of skin and gradual closing of cavity Well two and a half years later

Case 13 W M, male, aged 61 years—Fibro osteoclastoma of the mandible November 1946, swelling of right lower alveolus involving mandible of two months duration *Drill biopsy* preceded by radiation 500r partly osteoclastoma partly osteitis fibrosa January 1947, tumour removed no other treatment January 1948 well Radiographs show some consolidation of bone at the angle of the lower jaw

Case 14 A R, male, aged 42 years—Osteoclastoma of the tibia (Figs 11–14) May 1945 increasingly severe pain in the right knee for ten weeks *On examination*—hot tender swelling of upper end of the right tibia possibility of osteogenic sarcoma or malignant synovioma considered *Drill biopsy*—osteoclastoma May 1945, radiation treatment 3070r eleven treatments in twenty-eight days October 1947 well walking *Comment*—The pain and loss of function were so marked that the only alternative to X-ray treatment was amputation Radiographs suggested initial increase in size of the tumour

Case 15 R B, male, aged 23 years—Osteoclastoma of the ilium Operated upon in 1923 for "sarcoma of left ilium histology revised in January 1944 proved that it was an osteoclastoma *Radiographic appearances*—constant for many years Forty-two exposures to irradiation between 1932 and 1939 total dose about 16 000r to skin three or four fields Well until April 1946 when he developed pain down the right leg June 1946 ulceration at the centre of the scar, ulcer did not heal deep sinus January 1948 cavity in bone *Biopsy*—1) pieces of bone invaded by vascular and cellular growth the cells are of the small round type with dark nuclei and uniform arrangement similar to those of Ewing s sarcoma 2) piece of skin shows marked fibrotic changes and infiltration with plasma cells and lymphocytes no evidence of malignancy (Dr T Jockes) February 1948, ulcer healing *Comment*—Repeated radiation over a long period together with scarring due to operation caused radio-necrosis Subsequent healing suggests that the biopsy report really indicates an inflammatory lesion

Case 16 B R, female, aged 11 years—Osteoclastoma of the maxilla January 1934, tumour at the side of the nose displacing the eye outwards, 3 5 cm × 2 cm *Open biopsy* with insertion of radium needles into tumour mass 7000r given to the periphery other parts received larger doses *Histology*—osteoclastoma No trouble well fourteen years later

Case 17 M B, female, aged 18 years—Osteoclastoma of the maxilla December 1934 swelling of the upper jaw involving most of the left side and crossing the midline *On examination*—tumour of left alveolus and hard palate Curettage (Mr Wilkinson) and insertion of radium, 7000r to walls of cavity *Histology*—osteoclastoma Developed osteomyelitis Sequestrum removed after seven months leaving a cavity in the upper jaw involving the alveolus from the right incisor region to the third molar opening into the right antrum Obturator fitted Well ten years later *Comment*—Infection and delayed healing due to radium

Case 18 M R, female, aged 27 years—Osteoclastoma of the radius (Fig 17) December 1938 pain in the left wrist for some months gradual onset *Radiographic examination*—osteoclastoma thought possibly to be malignant no histological examination January 1939 radiation treatment 3500r in three weeks Well after ten years *Comment*—By a chance discussion this patient was saved from amputation of the hand The tumour is not considered ever to have been malignant

Case 19 E W, female, aged 39 years—Osteoclastoma of the mandible October 1928 tumour removed from right mandibular ramus 55 mg radium for two days Well for five years then pain in the right upper jaw and cheek radiating into the cranium *Histology*—osteoclastoma February 1936 slight swelling of right supra-orbital region radiographic examination showed destructive lesion of the skull March 1936 radiation treatment 5000r symptoms relieved but recurrence of pain after one year February 1940 died from brain abscess *Comment*—Without autopsy the possibility of connection between the osteoclastoma and death is unsettled

Case 20 J S, male, aged 67 years—Osteoclastoma of the tibia July 1939 pain and swelling of knee for eight months *On examination*—thickening of upper end of tibia radiographs show well-defined cystic area with trabeculation some expansion appearances consistent with osteoclastoma July 1939 radiation treatment 3000r in three weeks June 1940 died from meningococcal meningitis

TABLE I

SUMMARY OF CASES OF OSTEOCLASTOMA TREATED BY IRRADIATION
(London Hospital Cases 1 to 15 Sheffield before 1939, Cases 16 to 21)

No	Sex	Age	Symptoms	Duration	Site	Histology (D=Drill biopsy)	Diagnosis	Treatment	Dose	Result
1	F	16	Swelling, 5×3 cm	8 months	Mandible	Osteoclastoma (D)	Osteoclastoma	X-rays	3000r — 15 months 3000r	Still swelling 3 5×3 cm Consolidating 4 years
2	F	19	Tender recurrence after curettage	2 years	Head of humerus	Osteoclastoma	Osteoclastoma	X-rays	3000r	Pain disappeared 7 weeks Well 3 years
3	F	11	Pain on putting foot to ground	3 weeks	Calcaneus	Fibro-osteoclastoma (D)	Osteoclastoma (? healing osteoclasis)	X-rays	3000r	Symptom free after 3 months Consolidated 3 years
4	F	14	Pain left shoulder after fall from bicycle	9 months	Left humerus	Fibro-osteoclastoma (D)	Osteoclastoma	X-rays	3000r Two courses	No relief of pain until after second course
5	M	13	Swelling of mandible occasional bleeding	3 weeks	Mandible	Osteoclastoma (D)	Giant-cell epulis	X-rays	3000r	Rapid improvement Well $2\frac{6}{12}$ years
6	M	14	Football injury Pain right fibula	5 weeks	Right fibula	Osteoclastoma	Osteoclastoma	Excision X-rays	2800r	Normal except for some weakness and aching of leg $2\frac{6}{12}$ years
7	M	11	Painless swelling right side of face	6 months	Maxilla	Osteoclastoma	Osteoclastoma	Antrotomy radon	4500r in 9 days	Normal No swelling 1 year
8	F	22	Pain in right knee after fall	6 weeks	Right femur		Osteoclastoma	X-rays	1) 2000r 2) 3000r	Pain relieved in six weeks after second course
9	F	22	Sudden pain left wrist after sudden grab at bannister	5 months	Left wrist	Osteoclastoma	Osteoclastoma	X-rays		Moist desquamation Permanent deformity

11	F	29	Intermittent pain left knee after injury	2 years	Left tibia	Early malignant osteoclastoma (D)	Malignant osteoclastoma	X-rays	3000r	... year ... viously malignant $1\frac{4}{12}$ years Then Died
12	F	34	Swelling right lower jaw	5 months	Mandible	Osteoclastoma	Osteoclastoma	Excision D X R	4000r	Gradual closing of cavity Well $2\frac{6}{12}$ years
13	M	61	Swelling right lower jaw	2 months	Mandible	Fibro-osteoclastoma (D)	Osteoclastoma	Pre-op D X R Removal	500r	Well 1 year
14	M	42	Pain right knee	10 weeks	Right tibia	Osteoclastoma (D)	Osteoclastoma	D X R	3070r	Well $2\frac{6}{12}$ years
15	M	23	Operation for 'sarcoma" 21 years	21 years	Left ilium	Osteoclastoma	Osteoclastoma	Surgery D X R	16 000r (skin)	Radio-necrosis 3 years
16	F	11	Tumour to side of nose	?	Maxilla	Osteoclastoma	Osteoclastoma	Surgery radium	7000r	Well 14 years
17	F	18	Tumour of upper jaw	?	Maxilla	Osteoclastoma	Osteoclastoma	Surgery radium	7000r	Osteomyelitis and sequestrum Well 10 years
18	F	27	Pain left wrist	Several months	Left radius		Osteoclastoma	D X R	3500r	Well 10 years
19	F	39	Swelling of jaw	?	Mandible	Osteoclastoma	Osteoclastoma	Surgery 1) Radium 2) D X R	55 mg for 2 days 5000r	Well for 5 years Died $11\frac{6}{12}$ years from cerebral abscess
20	M	67	Pain and swelling of knee	8 months	Tibia		Osteoclastoma	D X R	3000r	Died 1 year from meningococcal meningitis
21	M	68	Gradually increasing swelling face	7 months	Maxilla	Osteoclastoma	Osteoclastoma	D X R	5000r	Residual bone expansion 5 months Died Uraemia and retention of urine

During this period five other cases believed to be osteoclastomas of bone, were treated successfully but they have been excluded because the diagnosis was not definitely confirmed

Fig 15

Fig 16

Case 9 Female aged 22 years Osteoclastoma of the radius confirmed by open biopsy (Fig 15) The tumour was curetted and then treated by radiation It healed but radiographs four years later show that it proved impossible to prevent deformity (Fig 16)

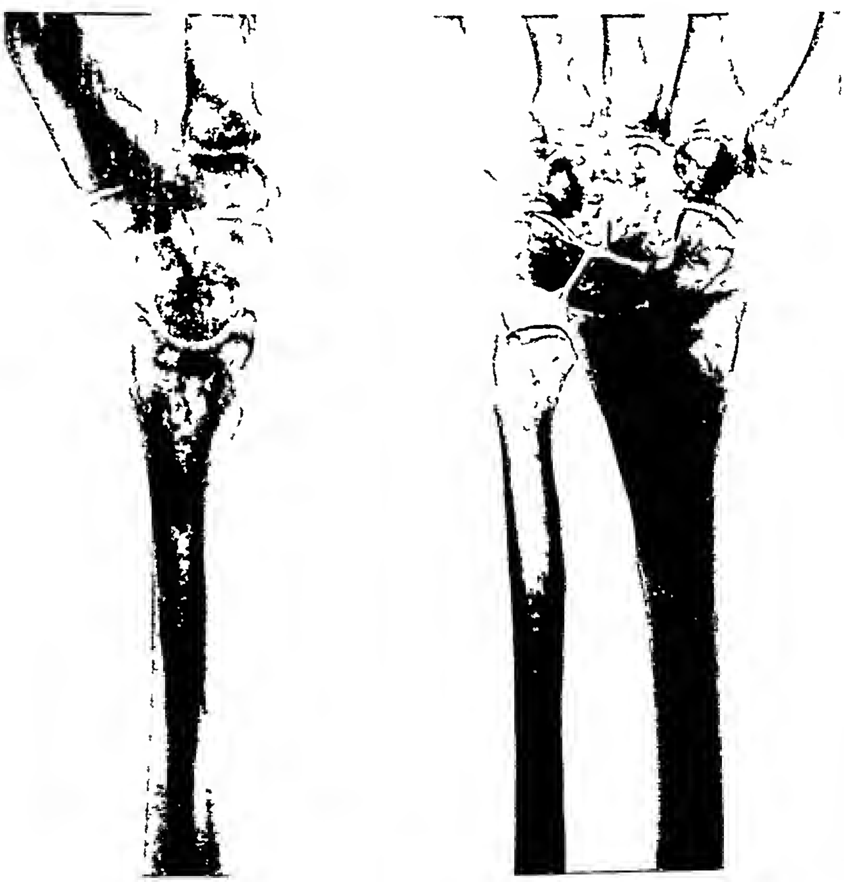

Fig 17

Case 18 Female aged 27 years Osteoclastoma of radius treated by irradiation alone (3500r in three weeks) Radiographs ten years later show complete healing without deformity

Case 21 F P, male, aged 68 years—Osteoclastoma of the maxilla March 1938, swelling right maxillary region of seven months duration occasional bleeding from nostril, no other symptoms no loss of weight history of injury to nose forty-eight years previously *On examination*—tumour of maxilla with spread to soft tissue between cheek and alveolus bone expanded *Biopsy*—osteoclastoma March 1938 radiation treatment 5000r August 1938 well some residual bone expansion Died from uraemia due to retention of urine from urethral stricture

DISCUSSION

The advantages claimed for treatment by irradiation are that it is curative, painless, free from unfortunate complications, and capable of being used without necessarily admitting the patient to hospital An obvious disadvantage lies in the fact that complete histological study of the tumour tissue is not available This, however, may be overcome by using drill biopsy before treatment is begun Other possible disadvantages such as extension of the lesion after treatment, malignant transformation, and disturbance of epiphysial growth, call for further discussion

Apparent extension after radiation—Several authors have drawn attention to apparent deterioration, which may be shown in radiographs during the first eight or twelve weeks after treatment, and which is then followed by recalcification during the next two or three years In only two cases in the series now reported was this seen (Fig 12) It is evident, therefore, that apparent extension of growth does not always occur after radiation and that, if it does, it should not be the signal for ill-advised surgery

Malignant transformation—It has been suggested that radiation may cause malignant transformation of an osteoclastoma It appears more probable, however, that when this is suspected the tumour has been malignant from the start Whether or not malignant osteoclastoma occurs as a primary tumour is still a matter of discussion among pathologists, the possibility is accepted by some, whereas others take the view that it represents a form of osteogenic sarcoma

If intermutability of the cells taking part in osteogenesis is accepted, there seems every possibility that a malignant process, starting as an osteoclast, may give rise not only to other malignant osteoclasts but also to other malignant cells such as fibroblasts and osteoblasts which are characteristic of osteogenic sarcoma More definite evidence is available from the reported cases of malignant osteoclastoma in which metastases consisted of deposits indistinguishable from the primary osteoclastoma and of almost benign appearance (Finch and Gleave 1926) Case 11 of this series is of special interest It was thought at first to be a benign osteoclastoma, but it soon proved to be malignant and metastasized (Figs 7–10) The case is discussed in this number of the Journal by Professor Dorothy Russell The question remains whether the malignancy was in any way the consequence of radiation It is well known that radiation can give rise to genetic changes in cells and, presumably, a genetic change could result in malignancy But malignant changes due to radiation in skin and connective tissue are reported as occurring only after long intervals and in the presence of profound tissue changes Moreover, malignant change is unknown after radiation of essentially benign lesions such as infections, and degenerative conditions such as arthritis For these reasons it seems unlikely that radiation could be responsible for rapid malignant change in a benign osteoclastoma If, as a result of radiation, osteoclastomata were more prone to become malignant than other lesions one would expect it to have been reported with greater frequency Moreover, of the cases in which malignant transformation after radiation has been reported, none can be accepted if there has been no preliminary biopsy because clinical and radiographic appearances alone cannot be relied upon in establishing the diagnosis of benign osteoclastoma

Effect of radiation on epiphysial growth—It has been shown in animals that radiation may cause arrest or delay of epiphysial growth (Wilkins and Regen 1934, Brooks and Hilstrom 1933) and the possibility of similar growth disturbance in young children must be borne in mind This author's view is that the possibility of such a complication makes it unwise to treat a simple bone cyst by radiation in a child less than ten years of age but that, in true osteoclastoma, radiation is justified even in early childhood At present there is no clear evidence that radiation, in the dosage commonly employed, gives rise to significant growth change in the human being, and in a wide personal experience of treatment by radiation there has been no case in which such an effect was observed

Summary of the management of a suspected case of osteoclastoma—After clinical and radiographic examination, and the completion of blood chemistry tests, the diagnosis is confirmed by drill biopsy, this being preceded by irradiation with a dose of approximately 300r if it is suspected that the tumour might be malignant If histological examination of the biopsy specimen shows few osteoclasts, and a relatively large proportion of spindle cells, treatment may be unnecessary and it is safe to wait, but if the diagnosis of true osteoclastoma is confirmed, treatment by radiation is begun at once The standard dose, including the pre-biopsy dose, in most cases reported in this series has been 3000r , but it is quite possible that 1500–2000r may usually be sufficient These are the doses received by the tumour, the necessary skin dose varying according to the number and arrangement of fields and the physical dimensions of the region As a rule no other treatment is required If there is serious structural weakness, or a pathological fracture, suitable orthopaedic measures are of course needed Recalcification usually occurs gradually and progressively over a period of from one to two years If this is not so, a second course of treatment may be given

SUMMARY

The problems of diagnosis and treatment of osteoclastoma are considered The importance of full investigation, and the advantages of drill biopsy in confirming the diagnosis, are discussed Treatment by radiation is believed to be better than treatment by surgical measures Curettage and excision are unnecessary Amputation for benign osteoclastoma is unjustifiable

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MALIGNANT OSTEOCLASTOMA

And the Association of Malignant Osteoclastoma with Paget's Osteitis Deformans

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It is generally conceded that solitary osteoclastomata of long bones may occasionally prove malignant, but there is no agreement as to the frequency of this occurrence or as to the diagnostic criteria of the histological appearances of malignancy in primary growths Clinical evidence of pulmonary metastasis has been recorded in a number of cases published during the last thirty-five years after curettage of the primary tumour, irradiation, and amputation of the limb, but unfortunately autopsy has seldom been performed The well documented case of Finch and Gleave (1926) was the first metastasizing osteoclastoma to be verified histologically (the case reported in 1922 by Auge and Roux being in all probability an osteogenic sarcoma) Dyke (1931), and Orr (1931), reported single cases which should also be accepted, though each was incomplete in certain respects In other relevant papers of this period, pathological observations were confined to the primary tumour It is generally agreed that the character of the cellular matrix, or the so-called " stroma cells " as distinct from osteoclastic giant cells, demands careful scrutiny in the assessment of malignancy In certain examples, such as those reported by Stone and Ewing (1923), Coley (1924, Case 3), and Stewart *et al* (1938, Case 3), these stroma cells may at first be indistinguishable from those of a benign growth, but subsequent biopsies show malignant characters such as marked polymorphism of the cells and their nuclei, increasing numbers of mitotic figures, and the formation of a distinctive and malignant type of giant cell to which attention was drawn by Mallory (1911) and, more specifically, by Stewart (1914) In other examples, the stroma cells displayed malignant features at the first biopsy (Kleinberg 1939) or there were appearances that proved controversial and at a later date declared themselves as frankly malignant (King 1932, Stewart *et al* 1938, Cases 1, 2, 5, 7) Jaffe *et al* (1940) went so far as to attempt grading the primary tumour on the basis of these changes in stroma cells, a procedure that appears valueless in the light of personal experiences to be related in this paper

A survey of the material preserved in the Bernhard Baron Institute of the London Hospital since 1907 shows that, excluding osteitis fibrosa, the surgical specimens include forty-six solitary osteoclastomata in bones other than the jaw Only one example of osteoclastoma came to necropsy, namely Case 4—osteoclastoma complicating Paget's osteitis deformans The subsequent history of many of these patients is unknown, but two are alive and well thirty-three and thirty-four years after amputation The second of these cases is of interest because the tumour, which was situated in the lower end of the humerus, showed a cellular stroma with many mitoses in the growing edge, and the adjacent muscle was infiltrated by the growth Such infiltration is not, however, uncommon in osteoclastomas and it has not the same sinister significance as infiltration in other types of tumour

Five cases have been selected for detailed consideration—two osteoclastomas of the upper end of the tibia, treated along parallel lines by curettage, irradiation, and amputation, in which metastasis supervened, and three osteoclastomas of histologically malignant character complicating osteitis deformans (Paget's disease)

TWO CASES OF MALIGNANT OSTEOCLASTOMA

Case 1 S K , female, aged 29 years—The clinical particulars of this case are recorded by Ellis (1949) in a separate communication in this issue of the Journal *Pathological examination*—The available material consisted of two drill biopsies taken at an interval of eight months, and the amputation specimen

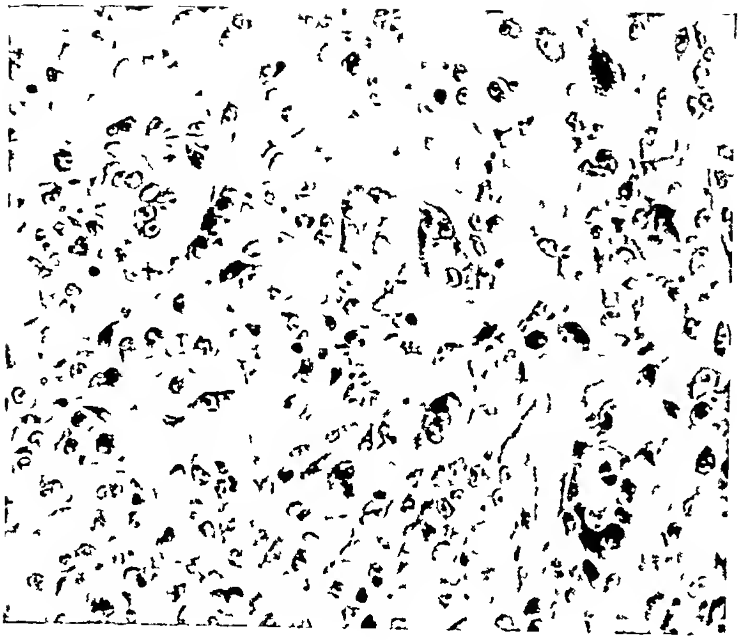

FIG 1

Case 1 First drill biopsy Reported as osteoclastoma (haematoxylin and eosin ×330)

received fourteen months after the first biopsy Later, there was radiographic evidence of pulmonary metastasis but when the patient died there was no necropsy *The first drill biopsy* was composed of small fragments of a cellular tumour containing osteoclastic giant cells of variable size most being rather small and containing from six to twelve nuclei These cells were distributed throughout the tissue, more numerous in some areas than others They were separated by polygonal stroma cells which varied in size and exhibited a few mitoses Their nuclei were even in form and chromatin content and there were no features suggestive of malignancy (Fig 1) The specimen was reported as "osteoclastoma *The second drill biopsy*, received eight months later presented similar appearances with many osteoclasts of large size throughout the tissue But the stroma cells though similar exhibited many more mitoses including abnormal forms Moreover the chromatin content of the nuclei was variable Some cells appeared to be multinucleate but close crowding made it difficult to assess the number (Fig 2) This specimen was suspected of malignancy and it was reported as probably malignant osteoclastoma *Amputation specimen*—Amputation was performed six months later through the upper thigh There was an ill-defined swelling below the knee due to a growth that had almost completely destroyed the upper end of the tibia and extended widely into the soft tissues and muscles of the calf capsule of the knee joint, soft tissues between the tibia and fibula and bone of the inner aspect of the fibular head Much of the tumour was soft opaque pink and necrotic, a few areas were rubbery, pale yellow and slightly bony The more peripheral parts were soft and white including a distinct area of tumour, 8 centimetres in diameter occupying the lower third of the tibia and projecting through the inner cortex and periosteum There was normal adipose marrow in the shaft immediately above and below this area *Microscopic examination*—Six blocks taken from representative parts of the tumour showed extensive destruction of tissue with haemorrhage and necrosis Osteoclastic giant cells were abundant in many areas and sparse in others They were separated by plump polygonal stroma cells which varied greatly in size and shape and in the size and chromatin-content of their nuclei (Fig 3) In some fields they were angular with a deeply basophil cytoplasm There were many multinucleate giant cells obviously derived from these stroma cells but the relationship between these giant cells and the osteoclastic giant cells was by no means clear and the more close the study the more difficult was it to avoid the

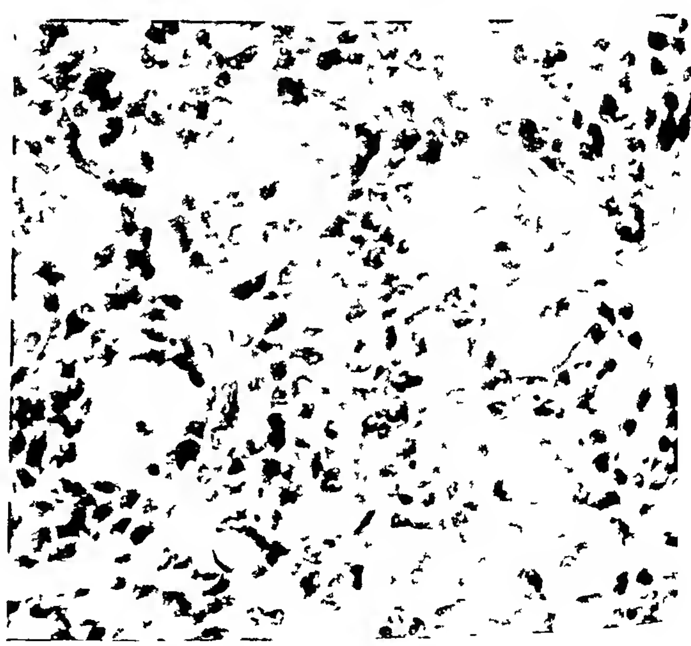

FIG 2

Case 1 Second drill biopsy, eight months later Osteoclast giant cells and plump closely crowded stroma cells Reported: probably malignant osteoclastoma (haematoxylin eosin ×330)

conclusion that there were transitions between the two (Fig 4) Osteoid tissue was present in many areas, forming a coarse net between the plump stroma cells In a few places calcium had been deposited and there was early coarse-fibred bone No cartilage or myxomatous tissue was identified

Comment—The three specimens from this case showed steady progression from an apparently benign to an obviously malignant tumour It is true of course that drill biopsy provides no more than scanty material for diagnostic purposes but the appearances in both drill specimens were sufficiently dissimilar from each other and from any field examined in the six sections taken after amputation from the main tumour, to justify the conclusion that they were representative preparations The histological appearances in the terminal stage were suggestive of osteogenic sarcoma but osteoclastic giant cells were more numerous and of wider distribution than would have been expected in such a tumour Nevertheless if the tumour had *first* been examined at this stage the differential diagnosis would surely have been controversial

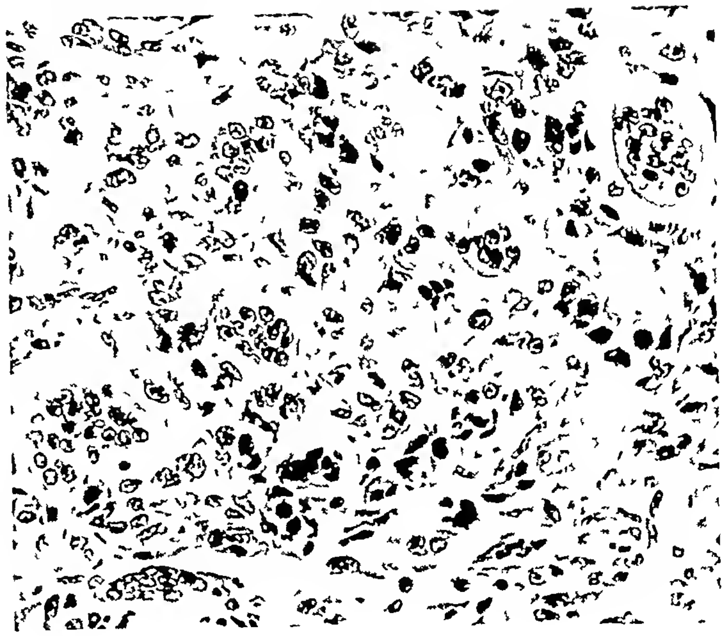

Fig 3

Case 1 Section of tumour after amputation, showing characteristic osteoclastic giant cells and polymorphism of stroma cells (haematoxylin and eosin, ×240)

Case 2 J L, girl, aged 19 years—Patient was never admitted to this hospital and full clinical notes have not been traced The primary tumour was first observed in November 1939, after there had been pain over the inner aspect of the upper right tibia with no history of injury There was a tender 'fluctuating swelling A small biopsy specimen described as "cortex and scrapings from bone cyst was received by my colleague, Dr W W Woods at the Emergency Medical Service Laboratory Southend The serum-calcium was estimated and found to be 9 4 mgm per cent, thus excluding generalised osteitis fibrosa In April 1940 the cyst was curetted and filled with iliac bone chips In January 1941 it was noted that she was walking well but in April 1941 two small sequestra separated A course of radiation treatment was given In July 1941 the limb was amputated through the middle third of the thigh The fate of this specimen cannot be traced and no histological report is available In May 1942 she was admitted to the Connaught Hospital under Mr W Welply with haemoptysis radiographic evidence of three 'golf-ball secondary deposits in one lung and a subcutaneous metastasis in front of the left ear which was excised for histological examination She died in August 1943 four years after the primary tumour was first observed Necropsy was not performed

Pathological examination—Pathological material was limited to biopsy of the primary tumour in 1939 and of the preauricular metastasis excised in 1942 The first biopsy specimen consisted of fragments of bone, the

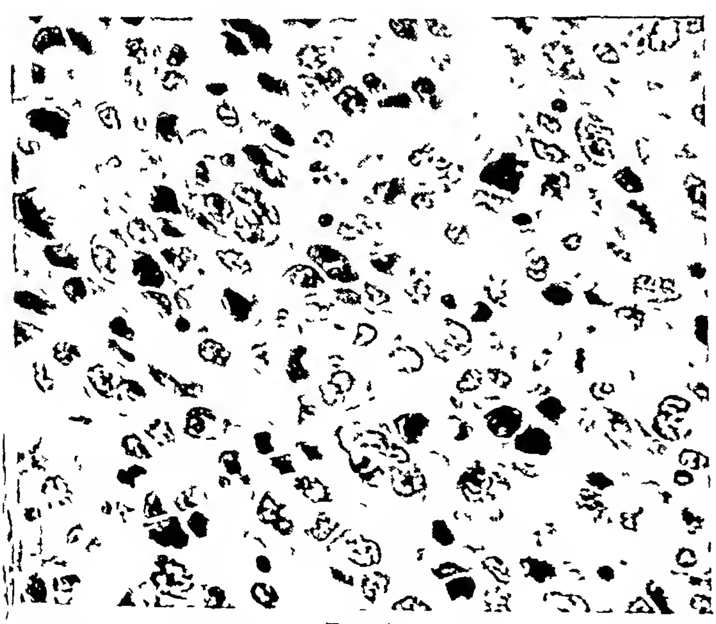

Fig 4

Case 1 Another field of the section after amputation showing stroma cells and transitions between these and osteoclastic giant cells (haematoxylin and eosin ×440)

trabeculae being separated by many osteoclastic giant cells in a spindle-celled matrix (Fig 5) Other areas were composed of dense fibrous tissue and bone trabeculae separated by spindle cell There were many pigment-macrophages No mitoses were present and there were no giant cell other than osteoclasts *Macroscopically* the second specimen consisted of a dome-shaped swelling

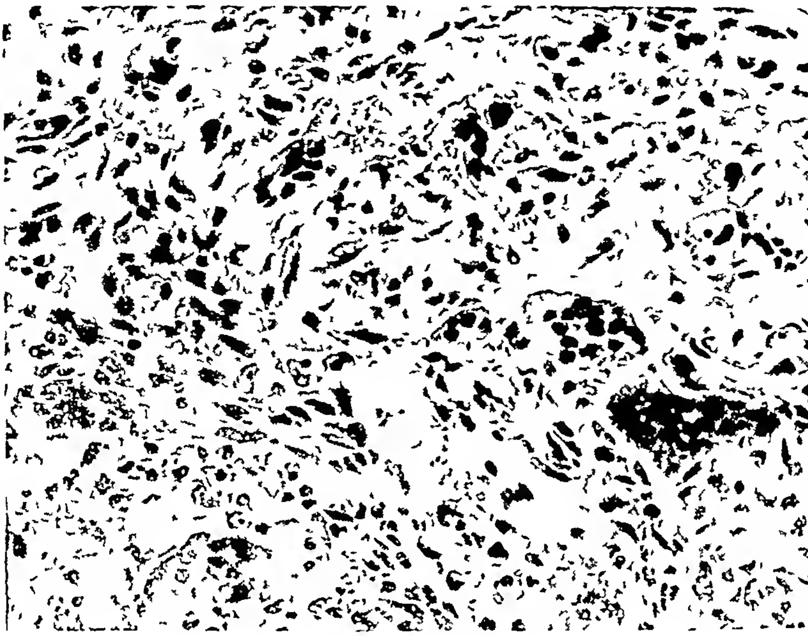

FIG 5

Case 2 Biopsy from the primary tumour of the tibia—osteoclastic giant cells in a spindle-celled matrix (haematoxylin and eosin, ×290)

FIG 6

Case 2 Subcutaneous metastasis of the tumour showing, on the left the border of a blood space, and on the right, osteoid tissue with a trabecula of coarse-fibred bone (haematoxylin and eosin ×110)

1 3 centimetres in diameter projecting into the skin On section there was a well defined ma 2 centimetres in diameter, consisting of haemorrhagic and grey tissue containing gritty particle *Microscopically* the tumour expanded the dermis and was well-defined above and below by circumferenti collagenous tissue The lateral borders were less sharp and were occupied by fine trabeculae of coar

fibred bone embedded in collagenous tissue containing spindle cells Similar foci of bone lay nearer the centre much of which was composed of large irregular blood spaces lined by cellular tumour tissue (Fig 6) In this large osteoclastic giant cells were conspicuous, associated with closely packed round, ovoid and polygonal mononuclear stroma cells containing nuclei of even shape, size and chromatin-content, except where they had become pyknotic and angular (Fig 7) Occasional mitotic figures were present but there were no giant forms More remote from the blood spaces the cellularity of the tumour tissue was reduced the cells were more frequently spindle-shaped and osteoclasts were less abundant Mitotic figures were rare Such areas merged into the still less cellular areas which were rich in collagen and associated with bone formation Reticulin fibrils were abundant throughout the tumour, separating the smaller cells and enclosing the osteoclasts

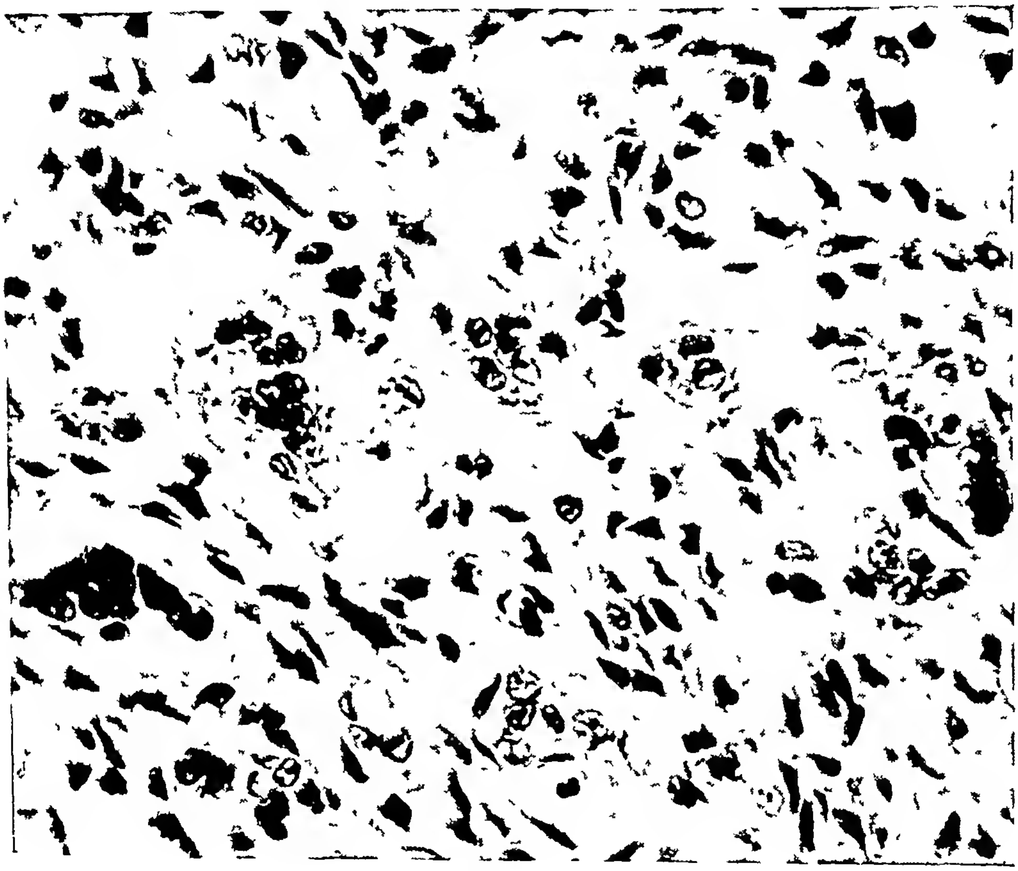

FIG 7

Case 2 Another field of the subcutaneous metastasis showing the character of the cells of the more cellular central areas (haematoxylin and eosin, ×620)

Comment—It is unfortunate that the amputation specimen could not be traced, particularly since the early biopsy specimen provided no more than meagre material for histological assessment It is clear, however, that the cellular character of the tumour showed no departure from that of the type generally accepted as benign Indeed, for a time, the diagnosis of osteitis fibrosa was considered The metastasis itself showed no obvious cytological evidence of malignancy and there is little doubt that if it had been presented to a pathologist as a primary growth it would have been labelled " benign " The case is therefore important, both in showing the difficulty of assessing malignancy in microscopic examination of the primary tumour, and in demonstrating that such benign features may be perpetuated in metastases Incidentally the metastasis shows clearly the osteogenic capacity of osteoclastoma

THREE CASES OF MALIGNANT OSTEOCLASTOMA IN PAGET'S OSTEITIS DEFORMANS

The association of malignant osteoclastoma with osteitis deformans (Paget's disease) does not appear to be recognised generally but, quite evidently, it accounts for a proportion of the malignant tumours that complicate this disease and it was represented in the record of this Department by three cases

Case 3 W H W, male, aged 70 years—The left lower limb was amputated through the hip joint at another hospital in 1931 for a tumour of the left upper femur Six months later a pulsating swelling appeared at the lower end of the right femur necessitating amputation through the right thigh A tumour was also observed in the lumbar muscles The patient died a few months later There was no necropsy

FIG 8

Case 3 Malignant osteoclastoma in Paget s osteitis deformans Tumour in the left femur

Pathological examination—The material available consisted of the left lower limb This showed antero-posterior bowing of the femur and tibia On section a polycystic tumour measuring 13 centimetres by 5 centimetres occupied the anterior aspect of the neck greater trochanter and upper part of the shaft of the femur (Fig 8) It had invaded adjacent muscles and completely destroyed the cortex for a distance of 6 5 centimetres Cystic spaces measured up to 3 centimetres by 1 7 centimetres and contained blood Their walls consisted of thin grey-yellow tissue of fibrous consistency The rest of the medullary cavity was occupied by gelatinous brown-red marrow The femur, tibia and fibula showed the characteristic changes of Paget s osteitis deformans *Microscopic examination*—The growth included large spaces filled with fresh blood, lined for the most part with large osteoclastic giant cells interspersed with spindle and polymorphic stroma cells Elsewhere the lining was composed of flattened cells of endothelial appearance The more solid parts of the growth contained similar osteoclastic giant cells in large numbers separated by plump polymorphic and spindle cells which varied greatly in size and shape (Fig 9) The nuclei of the cells also varied in size shape and chromatin-content Mitotic figures were numerous and there were conspicuous multinucleate giant cells of malignant type In some areas between the cysts there were conspicuo-

masses of pigment macrophages The tumour had invaded adjacent soft tissues and in many places, outside the confines of the bone osteoid tissue was laid down as a net between the polymorphic tumour cells Other parts of the bone showed stages of osteitis deformans

Comment—The cytology of this tumour is clearly indicative of its malignancy The many osteoclastic giant cells, and the situation of these cells in the walls of large blood spaces throughout the tumour, are characteristic of osteoclastoma The tumours that subsequently arose in the other femur, and in the lumbar muscles, were presumably metastases although it might be possible to interpret the second femoral tumour as being of independent origin

Case 4 W M, male, aged 49 years *Clinical history*—For eight years this patient had noticed thickening and bowing of the lower limbs below the knees Recently there had been headaches without vomiting and, during the week before admission numbness and loss of power in the right lower limb weakness of the right upper limb, and the appearance of a lump on the left side of the skull which was said to have grown larger Two days before admission there had been Jacksonian attacks starting with

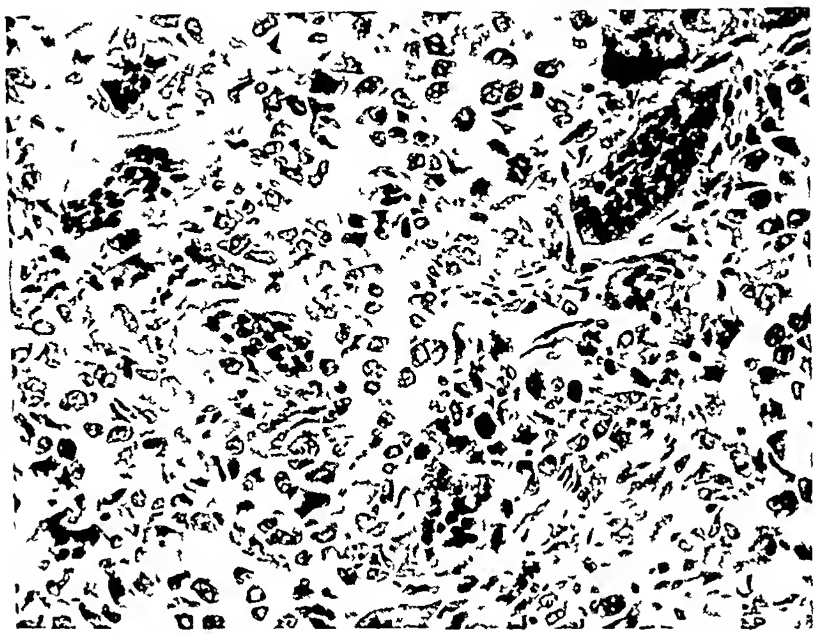

Fig 9

Case 3 Malignant osteoclastoma in Paget s osteitis deformans Osteoclastic giant cells and polymorphic stroma cells (haematoxylin and eosin ×210)

twitching movements in the right great toe extending up the right lower limb and then involving the right upper limb *On examination*—There was a tense pulsating painless swelling one inch in diameter over the postero superior angle of the left parietal bone The edge of the bone could be palpated about its margins The circumference of the head was 22 6 inches Both tibiae were thickened and bowed *Operation*—After reflection of the scalp a highly vascular growth was disclosed replacing the bone and invading the pericranium and parasagittal dura The tumour was partly removed Five days later motor power was regained in the right upper and lower limbs Two weeks later paresis returned with increasing involuntary movements Aphasia and incontinence developed and the patient died two months after admission to hospital *Necropsy*—*Bronchopneumonia Haemorrhagic tumour of the left parietal bone invading the subjacent cerebrum Osteitis deformans of the skull femora, tibiae and sternum* The vault of the skull which has been preserved as a museum specimen was diffusely thickened up to 1 3 centimetres but there was no additional expansion in the region of the tumour The margins of the bone showed a sharp transition to the tumour which formed a mass measuring 2 5 centimetres × 2 centimetres Half the tumour projected into the pericranium but did not penetrate beyond it The cut surfaces were homogeneous and grey The outer aspect of the dura showed a layer of similar tumour, several millimetres thick forming a fringe along the left border of the superior longitudinal sinus which was slightly deflected to the right The inner aspect of the dura showed a small mass of tumour 2 centimetres in diameter projecting into the angle between the sinus and the falx The tumour also extended through the cerebral cortex to reach the central white matter No metastases or other bone tumours

were observed *Microscopic examination*—Sections showed a highly vascular and cellular growth occupying the whole thickness of the bone and protruding into the pericranium Finger-like extensions occupied the adjacent diploe but, on the whole the margins were well defined The cytological characters of this part of the tumour and of the extensions towards the brain, were similar Large osteoclastic giant cells were numerous and widely distributed They were separated by closely packed spindle, ovo and angular stroma cells, which varied greatly in size Their nuclei varied in size and in chromatin conten Many mitoses and multinucleate giant cells of malignant aspect were present (Fig 10) There was muc destruction of the tumour by haemorrhage and necrosis No bone cartilage or osteoid tissue was detecte There were foci of dense collagen, elsewhere a fine network of reticulin fibrils separated the tumour cell The bone of the skull showed advanced osteitis deformans

Comment—The rapid deterioration of the patient after appearance of the growth and surgical exploration accord with macroscopic and microscopic appearances, both of whi are indicative of a malignant neoplasm

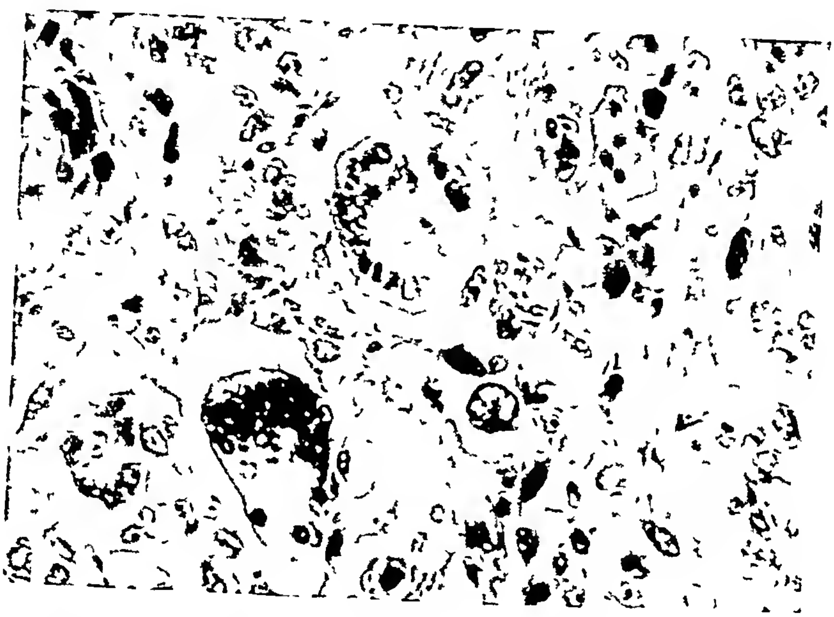

FIG 10

Case 4 Paget s disease with malignant osteoclastoma of the skull causing cerebral symptoms Two osteoclastic giant cells and polymorphic stroma cells of malignant appearance (haematoxylin and eosin ×330)

Case 5 E P, female, aged 59 years—Admitted to the London Hospital under the care of Mr Osmond-Clarke with Paget s osteitis deformans and a tumour of the left tibia *Clinical features*—For many years the left tibia left humerus skull and proximal phalanx of the right index finger had been affected by osteitis deformans For three months before admission after a blow on the upper end of the left tibia there had been continuous pain with gradual development of a pulsating swelling On admission the swelling measured 3 inches by 1 5 inches *Operation*—The limb was amputated through the middle of the thigh She made a good recovery and to-day, nearly two years later she is alive and well *Pathological examination*—*Macroscopic*—There was marked bowing of the leg Section showed a tumour in the medullary cavity of the tibia 9 centimetres in diameter composed of grey-white tissue with a yellow centre and containing patches of haemorrhage and one well-defined cyst near the upper end The anterior cortex was eroded over an area measuring 7 5 centimetres The posterior cortex was bayed by growth in several places No calcification was detected in the growth The rest of the bone showed the changes of osteitis deformans *Microscopic examination* showed a cellular tumour which had eroded the bone of the ti and extended into the periosteum but not beyond it Large osteoclastic giant cells were distribu throughout the tissue (Fig 11) They were separated by polymorphic angular, mononucleated c which varied greatly in size as well as shape Among these were many large multinucleate giant ce with relatively large vesicular often lobed nuclei of malignant type Some of these giant cells were large as the osteoclastic giant cells Mitotic figures were abundant There was extensive necrosis of th tumour in many areas No cartilage or osteoid tissue appeared to have been formed in the tumour I

one section there was a large irregular area of closely packed foam cells, apparently corresponding to the yellow patch seen with the naked eye A few polymorphic tumour cells were scattered among these foam cells

Comment—By all the usual criteria this was a highly malignant tumour, and the diagnosis lay between osteogenic sarcoma and malignant osteoclastoma The diagnosis of malignant osteoclastoma is favoured by the many characteristic osteoclastic giant cells, and the xanthomatous area within the tumour This interpretation is perhaps supported by the fact that the patient is in good health nineteen months after amputation

DISCUSSION

If the first two cases reported in this contribution are acceptable as authentic examples of metastasizing osteoclastoma, it follows that metastasis in this tumour is associated with

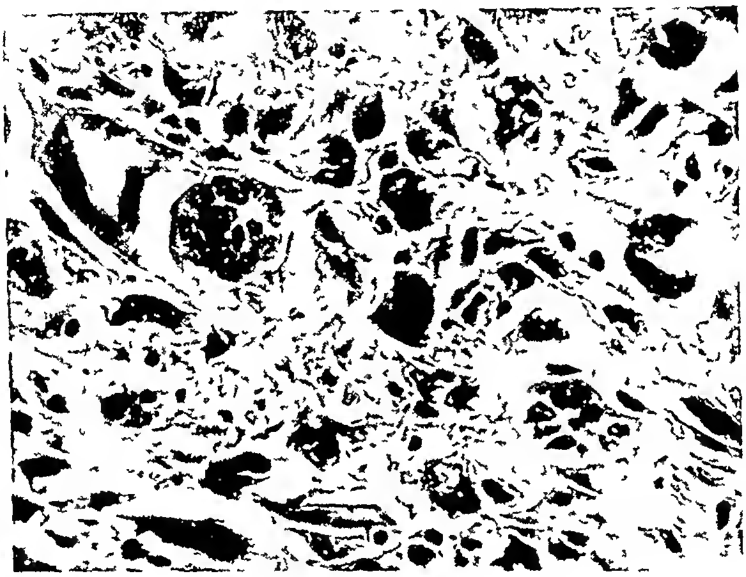

Fig 11

Case 5 Osteitis deformans with malignant osteoclastoma of the tibia Two osteoclastic giant cells are seen left of centre and right lower corner in association with polymorphic and giant stroma cells (haematoxylin and eosin, ×380)

two different types of evolution in the growth A frankly malignant change may take place in the stroma cells of the primary tumour with the production of cytological appearances that are difficult to distinguish from those of osteogenic sarcoma (Case 1), alternatively the tumour may proceed to metastasis without appreciable morphological changes in its cells (Case 2) Confirmation of the first is to be found in many published reports, and it is exemplified in the case reported by Finch and Gleave in which the metastases had malignant appearances In Dyke's case there was no detailed description of the stroma cells and the photomicrographs are at too low a magnification to rectify this omission Orr's case, in which the pulmonary metastases alone are described and illustrated, shows some resemblance to Case 2 of this paper in the character of the stroma cells which were for the most part spindle-shaped—" perhaps larger than the corresponding cells of the benign osteoclastoma " and a few showed mitoses

Further experience alone can decide whether these two types of metastasizing osteoclastoma are to be distinguished If such a distinction is confirmed it follows that no accurate prognosis can be based upon the histological appearances of a solitary osteoclastoma even although, by ordinary criteria, it may appear benign

Absence of bone formation has been regarded as an important diagnostic feature of osteoclastomata in general (Stewart 1922, Stewart *et al* 1938) However, osteoid tissue was present in the metastases in Finch and Gleave's case, and bone was reported in the metastase by Dyke The conspicuous amount of coarse-fibred bone in the subcutaneous metastasis in Case 2 of this series appears to establish the osteogenic capacity of the tumour cells This point is of fundamental importance in that it links osteoclastoma and osteogenic sarcoma more closely than has been conceded, and explains many of the difficulties of interpretation of malignant varieties of osteoclastoma

Finally the association of malignant osteoclastoma with osteitis deformans, as reported in Cases 3, 4 and 5 of this series, casts an interesting side-light on the disputed question as to whether or not a distinction should be drawn between the osteoclastomata that may be associated with generalised osteitis fibrosa and the solitary osteoclastoma that occurs without general bone disease Turnbull (1931), from study of many examples, was unable to distinguish the tumours of these two groups on a purely histological basis In Paget's osteitis deformans, a disease which in its early stages closely resembles osteitis fibrosa, he found that both osteoclastomata and cysts occurred, even although they were rare (Turnbull 1931–32) Malignant tumours of bone complicate osteitis deformans in a small percentage of cases, estimated by Geschickter and Copeland (1931) at 5 to 7 per cent These tumours are usually said to be osteogenic sarcomata Such a diagnosis may possibly be correct for Case 5 in this series, but it is believed on histological grounds, that malignant osteoclastoma is the true interpretation of Cases 3 and 4

I am indebted to Mr W R Welply for information about Case 2 and to Mr Osmond-Clarke for notes on Case 5 The photographs were prepared by Mr A J King

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9 CHONDRO-OSTEO-DYSTROPHY

Morquio-Brailsford Type

H A THOMAS FAIRBANK, LONDON, ENGLAND

This disorder is characterised by dwarfism with shallowness of the vertebral bodies, marked kyphosis, sometimes angular increase of the spinal curve at the dorsi-lumbar junction, and progressive changes in the femoral head and acetabulum in a child of normal intelligence It lacks the special features that are characteristic of the other type of chondro-osteo-dystrophy known as gargoylism To a varying extent the whole skeleton is affected, with the exception of the bones of the skull and face which are usually normal

The condition is generally associated with the names of Morquio and Brailsford Cases that we should now place in this group were undoubtedly published under various titles before 1929, but in that year Morquio described " A Form of Familial Osseous Dystrophy " seen in four members of a family of five, and Brailsford suggested chondro-osteo-dystrophy as a suitable title for the condition he found in one patient, the radiographic changes of which were described in detail In 1920, Wheeldon reported two patients with " achondroplasia " but with the unusual feature of a wedge-shaped vertebra which is so often a characteristic feature of both types of chondro-osteo-dystrophy, and one of these patients was later followed up and reported by Pohl (1939) as an example of Morquio's disease In 1925, at the Royal Society of Medicine, Thursfield showed " A Case of General Enlargement of Joints " which this author had seen with him, and which he published with illustrations in 1927, this case we should now place in the group under discussion Many others have since been reported

Hereditary and familial influences—Hereditary influences are seldom apparent, whereas familial influences are common Statistics vary because of differences of opinion whether not individual cases should be included Of the sixty cases known to this author, which he believes should be classified in the group, it was found that another member of the family was affected in about one-third Jacobsen (1939) reported twenty members in five generations of one family affected by a condition which, though not typical, appears to be allied closely with the Morquio-Brailsford syndrome

Sex—Both sexes are affected, males slightly more often than females

Age—Some abnormality may be present at birth (Hirsch 1937) but the developmental error is seldom apparent until the child begins to walk and appreciable changes are often first recognised at about the age of 4 years or even later Only six patients in the series studied by this author were seen under the age of 4 years, but thirty-six (60 per cent) were under 10 years of age

Etiology—The possible causes have been discussed by many authors but without any convincing evidence, and it must be acknowledged that the cause is unknown Ashby, Stewart and Watkin (1937) suggested that the disorder will eventually be included with gargoylism in the group of lipoidoses

Clinical characteristics—At about the age of 4 years it may be noted that there is curvature of the spine, failure to gain normal height, and the development of symmetrical deformities which increase, with progressive crippling, until the child is unable to walk without aid The typical appearances are those of a round-backed, knock-kneed, flat-footed child who stands with the hips and knees flexed in a crouching position, with the head thrust forward and sunk between high shoulders, looking not unlike a case of cervical caries, and walking in the waddling manner of a duck (Morquio 1929) The face is intelligent but perhaps inclined to conform to an almost characteristic type The bridge of the nose may be depressed and the eyes widely separated, the head may be large but it is usually normal in size and

shape, the neck is short. There is marked kyphosis of the spine with a short lordotic curve below. In about one-third of the patients there is angular accentuation of the kyphosis in the dorsi-lumbar region which may suggest caries of the spine, but pain in the back is most unusual. There is always limitation of movement, particularly of extension of the spine, and there may be scoliosis. The chest is narrow and the antero-posterior measurement is increased, the sternum being thrust forwards (pectus carinatum). Muscle weakness without changes in the electrical reactions has been noted. The spleen and liver may be felt rather easily but they are not enlarged.

Though the child is dwarfed generally, it is shortness of the spine that is chiefly responsible for the lack of height. The limbs are relatively long. It has often been recorded that in the standing position the hands reach almost to the level of the knees. Dwarfing of the proximal segments of the upper limbs, which is so marked a feature of achondroplasia, was noted in only one of the sixty cases. Some authors have said that there is congenital elevation of the scapula (Sprengel's shoulder) but their description of the mobility of the scapulae hardly agrees with the usual finding in this deformity.

The epiphyses are often but not always enlarged. In some joints there is limitation of movement whereas others show hypermobility, this variable feature being evident sometimes in different joints of the same patient. As would be expected from the radiographic appearances there is often stiffness of the hip joints and less frequently of the shoulders, knees, ankles, elbows, wrists, fingers and toes. General stiffness involving many joints was a feature in seven patients. Laxity of ligaments with hypermobility is seen most often in the wrists, fingers, feet and toes, and less often in the knees and ankles. It may be possible to dorsiflex the wrists until the fingers touch the back of the forearm. In one unpublished case of a boy aged 4 years, with widespread laxity of ligaments, several joints could easily be dislocated, and both patellae dislocated whenever the knee joints were flexed. Knock-knee and other deformities occur at the joint level, or close to it, and are not the result of bending of the shafts of the bones, they tend to become gradually worse.

The fingers are usually broad and blunt. Enlargement of the interphalangeal joints of the fingers was a striking feature in four patients, and to a less extent in a fifth, the swelling suggesting polyarthritis, but the enlargement was due to thickening of the bones and not to swelling of the joints. Widespread stiffness involving many joints was a feature of these cases (Thursfield 1925, Scott 1929, Ellman 1932, Hardwick 1938).

Pain is unusual, but as bone changes in the hip joints increase there is sometimes pain in this region which may be the first symptom responsible for the child being taken to hospital. *Blood examination* reveals nothing of importance. The serum calcium may be raised, lowered or normal.

Radiographic appearances—General porosis of the skeleton has often been noted. This is of no diagnostic importance and it is almost certainly no more than the result of limited activity due to crippling. The spine shows flattening of the vertebral bodies which may be more obvious in the dorsal than in the lumbar region. There is platyspondyly with increase in the transverse diameters, and particularly in the antero-posterior diameters, of the bodies. In lateral radiographs the bodies have a characteristic shape by which they can be distinguished readily from the typical vertebral bodies of gargoylism. The upper and lower surfaces are irregular, ill-defined and defective, with a tendency to approximate towards each other in front, thus accounting for a wedge-shaped appearance which is accentuated by a central prolongation, or tongue. Later on, multiple centres appear by which the defects are repaired and the epiphysial rings formed (Brailsford 1944). In the lumbar bodies, a layer of less dense bone has been seen above and below, with a more dense layer between (Guerin and Lachapele 1938). The typical shape is most obvious in the lower dorsal and upper lumbar regions, the lower lumbar vertebrae tending to be more normal in shape. When there is an angular kink in the spine, lateral radiographs show that one vertebral body

at the dorsi-lumbar junction is smaller than the others and is displaced a little backwards, as if it had been squeezed out of position by the bodies above and below This mal-alignment is always more obvious immediately above the small body than below it, in fact the appearance suggests that the spine above has slipped forwards on the small wedge-shaped body The first lumbar vertebra is most often affected in this way but the anomaly may be seen in the twelfth dorsal, and occasionally in the eleventh dorsal vertebra The second lumbar vertebra was the centre of a kink in one patient and the third lumbar vertebra in another The body next below the displaced one was also rather small in three cases (Summerfeldt and Brown 1936, Pohl 1939) the body next above was reduced in size in only a single, unpublished case As a rule, the intervertebral discs are relatively deep, but occasionally they are reduced in depth The pelvis may be narrow or shaped as in the ape The ribs are more horizontal than usual and they are expanded at both extremities

There is usually irregularity in outline of at least some epiphyses The hips are always affected, the changes becoming progressively more marked as the child grows The acetabula are enlarged and irregular The femoral heads are irregular, flattened and fragmented Sooner or later the femoral necks appear short, thick and spread, with coxa vara Examination of radiographs taken at intervals of three to six years in four cases in the author's collection shows not only that changes are definitely progressive but that the femoral heads may be normal to begin with and only later show signs of faulty development or degeneration There may be incomplete or complete dislocation of the hip joints on one or both sides In one patient there was no displacement of the femora at the age of 9 years and yet both hip joints were dislocated when re-examined at the age of 15 years Other epiphyses that sometimes show degenerative changes are those at the lower end of the femur, upper end of the tibia (Ruggles 1931) and upper end of the humerus, but it is only the changes in the hip joints that are important from the diagnostic point of view "Several" or "many" epiphyses were said to have been affected in seven cases It is also said that irregularity and fragmentation of the epiphyses may disappear later Delay or irregularity in ossification may be seen in the patella

The joint spaces appear to be unusually wide in younger children The shafts of the major long bones are usually normal but, occasionally, they are short and thick There was symmetrical thickening of the cortex on the outer side of the upper femoral shafts in one patient—a curious feature that has been seen in only two other patients, both suffering from gargoylism The metaphyses may be splayed to accommodate the enlarged epiphyses especially in the radius and ulna where the epiphysial lines at the lower ends are tilted towards each other The ulna, as in so many developmental errors, may be short The fibula may also be short, whereas in achondroplasia it is usually long

The metacarpals and phalanges are stubby, with expanded ends The bases of some metacarpals, especially the third and fourth, and the distal extremities of the phalanges, tend to be pointed There may be multiple centres of ossification for the epiphyses of the hands and feet Ossification of the carpus may be delayed and when the bones are ossified they may be irregular in outline There may also be irregularity in shape of the tarsal bones In one case, included with confidence in this group because of other skeletal changes, the great toes were abnormally long and large, the first metatarsals sharing enlargement with the phalanges (Thursfield 1925)

Changes in the skull are usually minimal and unimportant The pituitary fossa is usually normal, it has sometimes been found small and sometimes enlarged Digital markings in the skull were seen in two brothers in a family of eight children in which a third member showed signs of the Morquio-Brailsford affection

Progress—As a rule radiographic changes in the bones advance, and deformities progress, with increasing disability, until walking becomes impossible without assistance

Pathology—The pathology is unknown Shelling (1945) examined biopsy specimens from the lower femoral epiphysis and diaphysis in one case the epiphysial line was irregular,

there were cartilaginous nests within the bony trabeculae, and the matrix in these nests was striated and stained in an irregular manner Harris and Russell (1933) believed that mucoid degeneration of cartilage in place of normal calcification was the fundamental change in dwarfism including achondroplasia

Differential diagnosis—Many examples of Morquio-Brailsford chondro-osteo-dystrophy have been reported as cases of achondroplasia, with or without the prefix "atypical", but as a rule the appearances of the head and face in chondro-osteo-dystrophy are quite unlike those of achondroplasia In achondroplasia there is apparent lordosis with prominence of the buttocks, less secondary kyphosis, normal length of the spine, shortening of the limbs and particularly of the proximal segments, and usually bowing of the legs rather than genu valgum * There is seldom coxa vara in achondroplasia and there are never the gross epiphysial and articular changes seen in the Morquio-Brailsford affection The achondroplasiac patient is sturdy and strong, he is not feeble as are the patients discussed in this chapter

The special features of gargoylism, the other type of chondro-osteo-dystrophy, are the heavy facies, mental deficiency, cloudy corneae, and enlargement of the liver and spleen In gargoylism the spine may also show a kink in the dorsi-lumbar region with one vertebral body small and displaced backwards, but the shape of the bodies differs markedly from that seen in the Morquio-Brailsford type Very seldom is there difficulty in deciding to which group a case belongs after examination of radiographs of the spine, but the one described by Snoke (1933) is an exception

When many epiphyses are involved the condition must be distinguished from dysplasia epiphysialis multiplex in which the spine is usually normal and the acetabulum is not altered in the way that it almost invariably is in the Morquio-Brailsford syndrome Only one example of multiple epiphysial dysplasia with flattening of the vertebral bodies is known to the author When the patient complains only of the hip joints, local radiographic changes might suggest the diagnosis of pseudo-coxalgia were it not for the striking deformities of the trunk

Deformity in the dorsi-lumbar region due to wedging of a vertebral body may be seen occasionally in cretins, even in foetal life (Annual Report of the Institute of Social Medicine, Oxford 1946) The appearances in one patient, seen by the author, would suggest that the abnormality in shape of the vertebral bodies in cretins is of the type seen in gargoylism rather than that of chondro-osteo-dystrophy A similar local deformity of the spine has been seen in a child who appeared to be entirely free from other skeletal abnormalities

The distinction from spinal caries of the dorsi-lumbar region should be made without difficulty after examination of lateral radiographs of the spine It must be recognised, however, that a degree of dwarfism is a feature of several conditions, and atypical cases occur which, for the moment, it is difficult to classify with any degree of conviction

* It is true that in two unquestionable cases of achondroplasia there was an angular kyphosis at the dorsi-lumbar junction In one of these a vertebral body at the angle was smaller than the others But in neither were the vertebrae flattened and spread

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CASE 10—CHONDRO-OSTEO-DYSTROPHY (Morquio-Brailsford Type)

(Figs 22–26) Boy aged four and a half years Enlargement of joints and other deformities first noticed after an attack of bronchitis when six months old Did not walk until the age of three and a half years Family history negative Clinical features—kypho-scoliosis with

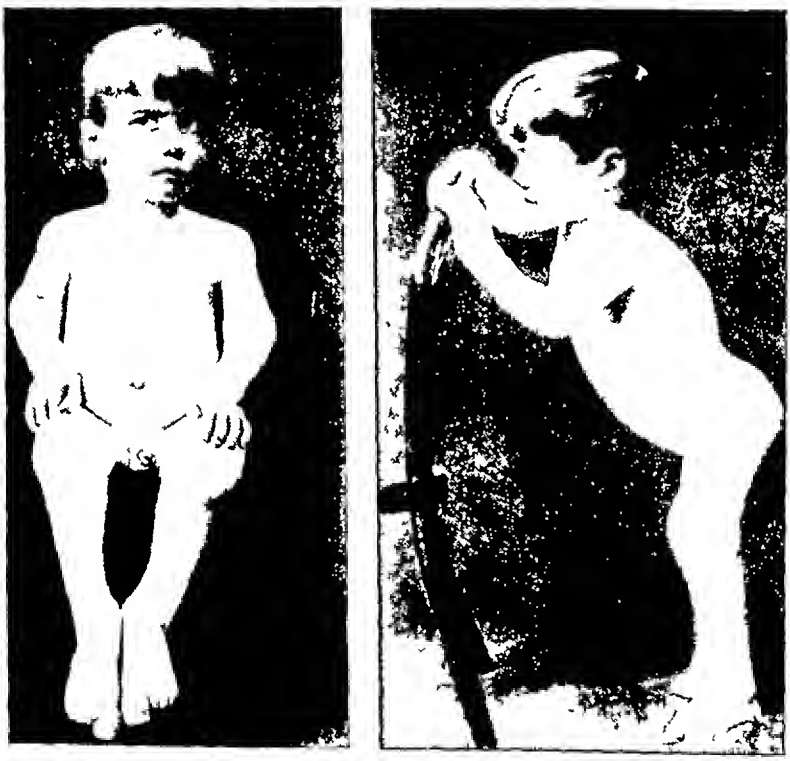

Fig 22

Case 10 Photographs of the child aged four and a half years showing thickening of the ends of the bones and lengthening of the great toes Note the kyphotic curve and the typical standing attitude with the hips and knees flexed

enormous enlargement of the epiphyses and lengthening of the great toes (an exceptional feature), some limitation of rotation movement at the shoulder joints and of pronation and supination of the forearm Fingers thick and stumpy, nails unusually short, unable to flex the fingers properly, especially at the metacarpo-phalangeal joints Backward child Head rather large (Under the late Dr Hugh Thursfield Reported Thursfield 1925, Fairbank 1927)

Fig 24

Case 10 Lateral radiograph showing increased antero-posterior measurement of the bodies disc spaces not unduly wide no abrupt kyphos at the dorsi-lumbar junction

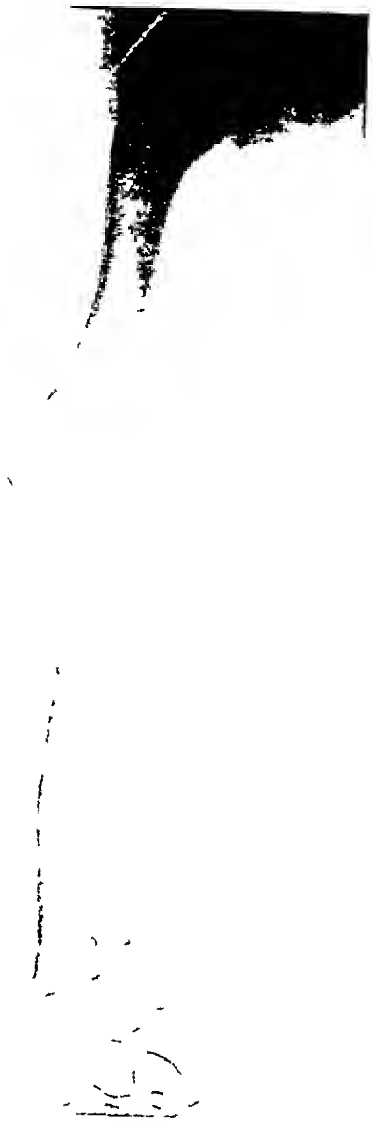

Fig 23

Case 10 Upper limb, showing the stout bones with enlarged ends and some irregularity of ossification of the epiphyses

Fig 25

Case 10 Enlargement of the great toes with irregular ossification at both ends of the first metatarsals and the proximal phalanges

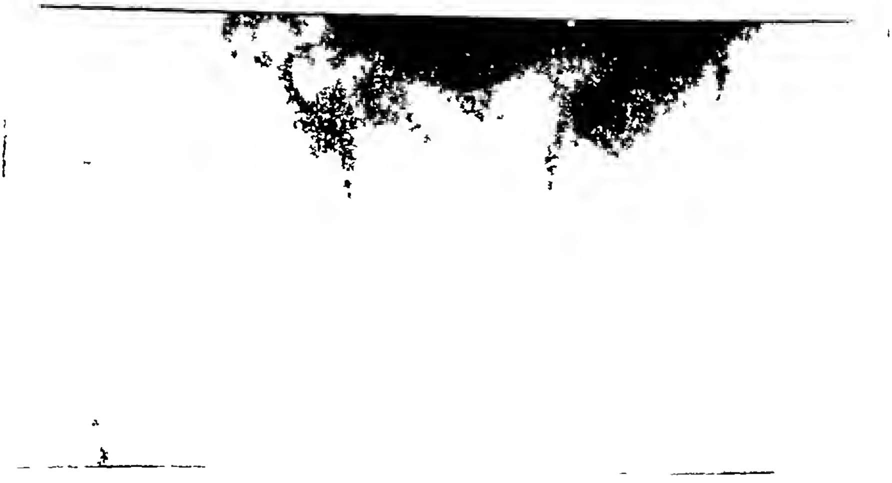

Fig 26

Case 10 Showing ape-like shape of the pelvis poorly developed acetabula and marked coxa vara with delayed and irregular ossification of the femoral heads

CASE 11 CHONDRO-OSTEO-DYSTROPHY (Morquio-Brailsford Type)

(Figs 27–29) Girl aged six years Sent to hospital for deformity of the wrists and spine Family history negative Head big, skull of normal shape, premature closure of sutures Rigidity localised to the dorsi-lumbar junction Femoral heads prominent, abduction of the hips not limited Genu valgum Abduction of the shoulder joints limited to 80 degrees Extension of the elbow joints slightly limited Forearms short, especially the ulnae, supination excessive Marked hypermobility of the wrist joints in all directions, the fingers can easily touch the flexor aspect of forearms Fingers and thumbs blunt (Under Mr H L-C Wood)

FIG 27

Case 11 Spine showing typical shape of the bodies with the central 'tongue' in front The second lumbar body is small and displaced backwards The discs are unusually deep

FIG 28

Case 11 All the long bones are rather short and stout Note shortness of the ulna and tilting of the lower epiphyses of both forearm bones 'Pointing' of the bases of the metacarpals is not striking in this case

FIG 29

Case 11 Pelvis and hip joints showing ape like shape of the pelvis large acetabula and only slight irregularity in the ossification of the femoral heads

CASE 12 CHONDRO-OSTEO-DYSTROPHY (Morquio-Brailsford type)

(Figs 30–34) Boy, aged nine and three-quarter years Deformity of the left hand, suggestive of rheumatoid arthritis, since birth Other deformities not noticed until the age of three or four years One sister was said to have deformities of the spine and hip joints, three other sisters normal Dwarfed Flat depressed nose, forehead prominent Teeth hypoplastic All epiphyses enlarged and joint movements restricted Complains of lumbar pain when the hip joints are flexed beyond 70 degrees General muscular weakness Blood investigations negative, but said to have had negative calcium balance treated successfully with calcium gluconate and vitamin D Marked kyphotic curve with angular accentuation at the dorsi-lumbar junction, the twelfth dorsal body being small and displaced backwards Marked changes in the head and neck of both femora no subluxation Irregular ossification in the epiphyses of the upper end of the tibia, lower end of the humerus (capitellum and medial epicondyle), lower end of the ulna and upper end of both humeri (Under the late Dr Gordon Pugh)

When examined at the age of fifteen years there was marked kyphosis with a short lordosis below which had improved his general posture, genu valgum, feet flat, general laxity of the knees, ankles, fingers, and particularly the wrists, feet blue and cold Skull broad forehead prominent Teeth good The outline of the vertebral bodies is now much more irregular in both antero-posterior and lateral films, and there is further destructive change in both femoral heads which are now subluxated (Under the late Sir Henry Gauvain)

Fig 30

Case 12 at the age of nine years Radiograph of the spine shows typical 'tongued' vertebral bodies The twelfth dorsal vertebra is reduced in size and is the apex of an angular kyphosis The second lumbar body approximates more closely in shape to the twelfth dorsal than do the others the eleventh dorsal body is slightly smaller than the bodies above it The discs are deep

Fig 31

Case 12 at 9 years showing mottling and fragmentation of the capitellum and internal epicondyle of the humerus

Fig 32

Case 12, at 9 years showing irregular ossification of the outer part of the tibial epiphysis

Fig 33

Case 12 At the age of nine years Radiographs of the pelvis and hip joints show that the pelvis is narrow and there is fragmentation and destruction of the femoral heads with thickening of the femoral necks The acetabula are large and poorly formed

Fig 34

Case 12 at the age of fifteen years The pelvis and femora show further changes in the femoral heads now with definite subluxation of both hip joints which was not present at the age of nine years (Fig 33)

CASE 13 CHONDRO-OSTEO-DYSTROPHY (Morquio-Brailsford type)

(Figs 35–38) Girl, aged five years Unwilling to walk far, cried with pain Enlarged joints and round shoulders since infancy Father's mother and sister both of short stature (both dead) Stiffness of the shoulder, elbow, wrist, hip and knee joints, some limitation of pronation and supination of the forearms Valgus deformity of feet Blood examination showed nothing of significance General dwarfism, limbs more affected than trunk Moderate kyphosis Little movement in the spine except in the cervical region Bridge of the nose sunken Forehead prominent Long bones stout, with splayed ends When the child standing the finger tips reach just below the greater trochanters

Fig 35

Fig 36

Case 13 Fig 35 shows the condition of the spine at the age of two years note the shape of the vertebral bodies the deep disc spaces, and the enlargement of the anterior ends of the ribs Fig 36 shows the condition at the age of five years there is irregularity in outline of vertebral bodies in the lumbar region the appearance suggests that less dense bone has been added above and below the rather less dense bodies previously present

FIG 37

Case 13 at the age of two years Radiograph of the pelvis and hip joints shows rather large acetabula and, for this age normally ossified though rather small centres for the femoral heads

FIG 38

Case 13 at the age of five years The pelvis and hip joints show progressive changes that were not present at the age of two years (Fig 37) Thickening of the cortex now seen on the lateral aspect of both femoral shafts is not believed to be significant

10 GARGOYLISM

Synonyms—Hurler's syndrome, Dysostosis multiplex

This type of chondro-osteo-dystrophy is characterised not only by dwarfism but also by a heavy, ugly facies, corneal opacity, mental deficiency, kyphosis, distension of the abdomen, and enlargement of the liver and spleen The first two cases were reported by C Hunter in 1917, the patients were brothers, neither had the corneal opacities that are so often a striking feature It is to Hurler that priority of description is often given She published two cases in 1919, both boys, one was investigated later by Tuthill (1934) who first published a detailed account of the neuropathology In 1933 Binswanger and Ullrich reported two cases and suggested the name "dysostosis multiplex" In 1936 Ellis, Sheldon and Capon, in a valuable contribution, reported seven cases and reviewed eight others previously published, they proposed the title "gargoylism" and suggested the possibility that a metabolic error might be responsible Many other cases have since been reported For this review fifty reported cases have been selected *Hereditary and familial influences*—There is little evidence that heredity plays any part but familial influences are common Familial incidence was a feature in thirty-two of sixty-two cases collected by Henderson (1940)
Sex—Both sexes are affected, males more often than females in the proportion of four to three
Age—Only three of the cases studied were under twelve months of age, the youngest being eight months, but 87 per cent were under ten years Few lived until growth was complete
Etiology—It is now agreed, fairly generally, that this condition must be classified with the lipoidoses, although endocrine dysfunction has also been suggested as an explanation of the somewhat complicated pathology which is characterised by changes in so many different tissues Henderson (1940) remarked that "hypothalamic disturbances are probably connected with the changes seen in the pituitary and thyroid glands, and these in turn with some of the clinical features of the disease such as chondrodystrophy and dwarfism" He agreed with Ellis (1937) that it is "yet too early" to assess the part played by the thyro-pituitary mechanism It is difficult to see how metabolic or endocrine error could account for the curious shape of vertebral bodies, and still less for local deformity of the spine Engel (1940) attributed the hypophysial dysfunction to "blebs" caused by escape of cerebro-spinal fluid into the adjacent tissues in early embryonic life He included in the "bleb diseases" a group of ten different syndromes It seems probable that the fault exists at birth but we have found only three reported cases that were recognised in the first year of life
Clinical signs—At birth, the size and weight of the child is often above the average but, after the first year, growth is restricted and there is usually, though not invariably, increasing evidence of dwarfism There is some degree of micromelia In a well-marked case the head is large, the eyes are wide apart, sometimes suggesting hypertelorism, the bridge of the nose is depressed and the general facies is heavy and ugly There may be prominence of the supraorbital ridges, bulging of the temporal regions, and ridges along the sutures and around the anterior fontanelles Scaphocephaly, acrocephaly, oxycephaly and brachycephaly have all been noted (Ellis *et al* 1936) Hydrocephalus occurs in more than one-third of cases The lips are everted, the mouth open and the tongue enlarged, so that many are suspected of cretinism In one patient there were fissures of the tongue and prominent papillae as in a mongol (Ashby *et al* 1937) The mandible is often large The eyebrows are coarse, dark and bushy, but the hair is usually fine and silky The ears are set low on the head Nasal discharge is frequent Dentition may be irregular and delayed Cloudiness of the cornea is a striking feature and, from the diagnostic point of view, important, it is caused by multiple opacities in the deeper layers of the cornea There may be lateral nystagmus (Slot and Burgess 1938) Buphthalmos has sometimes been reported Optic atrophy occurred in two siblings reported by Davis and Currier (1934) and there is sometimes deafness

There is often, but not always, mental deficiency. In some patients it has been noted that there was gradual mental deterioration in the course of a number of years. One girl, aged eighteen years, showed a very marked degree of statural, mental and sexual infantilism (Ellis *et al.* 1936). The neck appears to be short and the shoulders are high. Sometimes the deformity of the shoulders almost warrants the title of "congenital elevation of the scapula" (commonly, but quite unjustifiably, known as "Sprengel's shoulder"). The clavicles may be thick. As a rule there is marked kyphosis, angular in shape, in the dorsi-lumbar region. There is seldom scoliosis or pigeon-breast. The abdomen is distended to an even greater extent than could be accounted for by enlargement of the liver and spleen which is an important feature in most cases. The liver is more often enlarged than the spleen, both being smooth and firm on palpation. Quite often there are umbilical and inguinal herniae.

There is often limitation of movement of some joints, and occasionally of all joints (Davis and Currier 1934, Ellis *et al.* 1936). The upper limbs are more often affected than the lower limbs and in the shoulders, elbows, and particularly the fingers, there is not only limitation of movement but also flexion contracture. Claw hand was regarded as an important feature by Ashby *et al.* (1937). The fingers may be short, and the ring and little fingers incurved. There may be limitation of extension of the knee joint, genu valgum, genu varum, or flat-foot. The epiphyses are not enlarged as they so often are in the Morquio-Brailsford group. Sometimes, even in members of the same family, one patient may show all features of the syndrome while another shows only bone changes (Ellis *et al.* 1936).

Blood examination reveals nothing of importance. Biochemical studies have shown no constant abnormality.

Radiographic appearances—The radiographic appearances in gargoylism show general resemblance to the changes that are seen in Morquio-Brailsford disease, but there are distinct differences in the skull, the vertebrae and the hip joints.

The skull—Most cases of gargoylism show enlargement of the sella turcica, even to twice the normal size, with or without hydrocephalus. There is no evidence of erosion and it has been suggested that this enlargement is due to malformation of the sphenoid rather than to abnormality of the pituitary gland or increased intra-cranial pressure (Ellis *et al.* 1936).

The spine—In the spine, the upper and lower surfaces of the vertebral bodies are convex, so that they present a circular rather than a quadrilateral outline, the discs are biconcave and deeper than normal. It is often said that the bodies are spread and flat, as in the Morquio-Brailsford type, but this is not accurate. When there is angular kyphosis—and this occurs with far greater frequency than in the Morquio-Brailsford type—one body is usually smaller than the others and is displaced backwards as if squeezed out of line. The mal-alignment is always more obvious above the small body than below it: the vertebrae above appear to have slipped forwards on the small deformed body. This deformity is seen in both types of chondro-osteo-dystrophy but there is no other resemblance. The displaced vertebral body is concave on its anterior surface, the upper part being deficient and the lower part projecting forwards in the form of a beak. This beak is quite different, both in shape and position, from the central "tongue" seen in the Morquio-Brailsford type. The typical shape and displacement is seen most often in the second lumbar vertebra and, next in frequency, in the first lumbar vertebra; in only one case was the twelfth dorsal as well as the first lumbar vertebra small, beaked, and displaced. A similarly peculiar shape is often seen in the vertebral body next below the one displaced and occasionally in the one above it. This distortion, which is a diagnostic feature, is usually seen only in two or three of the upper lumbar bodies, but in two patients the first four lumbar bodies were all affected. In one patient the fifth lumbar vertebra showed typical deformity; in this case the first and second bodies and possibly the fourth were also affected, but the third lumbar vertebra was normal. Only one case has been found in which the shape of the bodies as seen in lateral radiographs failed to indicate clearly to which group of chondro-osteo-dystrophy the case belonged (Snoke 1933). If lateral

radiographs are taken when the spine is flexed it will be seen that much more movement takes place at the level of the disc above the small body than in the disc below

Angular kyphosis may be present without any vertebral body being small or displaced The ribs may be thicker than normal, particularly anteriorly In one case the lower ribs were said to be like Indian clubs (Slot and Burgess 1938) The long bones are often thick and of uniform density On the whole, the bones of the upper limb show greater change than those of the lower limb (Caffey 1945)

Hip joints—The hip joints show peculiarities that are quite different from those seen in the Morquio-Brailsford type The roof of the acetabulum is usually shelving but there is no gross enlargement or irregularity such as is seen in the other type There is coxa valga and the femoral necks are long The epiphysis for the femoral head may be deformed and irregular, particularly on the inner side, but it does not show the gross changes that are so characteristic a feature of the Morquio-Brailsford type The femoral heads may be displaced a little upwards but there is seldom true subluxation There may be irregularity of ossification of other epiphyses, particularly of the head of the humerus, and of the glenoid which is flat Ossification may be delayed and there may be delayed fusion with the shaft There is often delay in ossification of the carpus and the patella The lower ends of the radius and ulna may be deformed as in the Morquio-Brailsford type The long bones of the hands may be short, thick and honeycombed, with the bases of the metacarpals pointed Symmetrical thickening of the lateral aspect of the upper femoral shafts was seen in two cases, but precisely similar thickening was seen in one case of the Morquio-Brailsford type of chondro-osteo-dystrophy

Progress—Sometimes the condition remains stationary but as a rule there is gradual deterioration and the child dies before growth is complete Five patients ranging in age from one to three and a half years all died before reaching the age of eight years

Pathology—Tuthill (1934) first recorded the finding of lipoid in the brain with changes corresponding to those of juvenile amaurotic idiocy Ashby *et al* (1937) reported autopsy findings in two cases and confirmed these observations they did not find evidence of lipoid deposit outside the nervous system but thought nevertheless that the condition must belong to the lipoidoses they suggested that the lipoid was not in pure form but was combined with protein and they found changes in the thyroid gland and were convinced that in both cases there must have been hypothyroidism Kressler and Aegerter (1938) are credited with the first demonstration of extra-cerebral lipoids in the liver spleen cornea and pituitary but not in the bones

Diagnosis—The distinctions between gargoylism and the Morquio-Brailsford type of chondro osteo-dystrophy have already been discussed Differentiation from cretinism, which has often been the first diagnosis is made more difficult by the fact that angular kyphosis with diminution in the size of one vertebral body may sometimes be observed in a true cretin On two occasions we have seen a similar spinal deformity in patients with all the signs of achondroplasia but without the other features of gargoylism Congenital syphilis can be excluded by the Wassermann reaction and by the entirely different appearance of the bones (Ellis *et al* 1936) In one case reported by Ellis *et al* there was a suspicion of acromegaly because the facies was suggestive and the pituitary fossa was large, but such differentiation should soon be made easy when it is recognised that in chondro-osteo-dystrophy growth is retarded and not accelerated

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CASE 14—GARGOYLISM

(Figs 39–43) Male, aged two and a half years Deformity of chest noticed at nine months, becoming worse Kyphosis present at eleven months Head large, facies heavy Backward but no gross mental deficiency, squints Limitation of movement of some joints, especially the shoulders Hands spade-like, fingers curved Stands with hips and knees flexed Knock-knee No corneal opacities Liver and spleen not enlarged Umbilical and left inguinal herniae Radiographs sella enlarged, spine typical of gargoylism with lumbar kyphosis, clubbing of lower ribs, bilateral coxa valga, metacarpals of typical shape Two other children both normal (Under Mr Eric Lloyd)

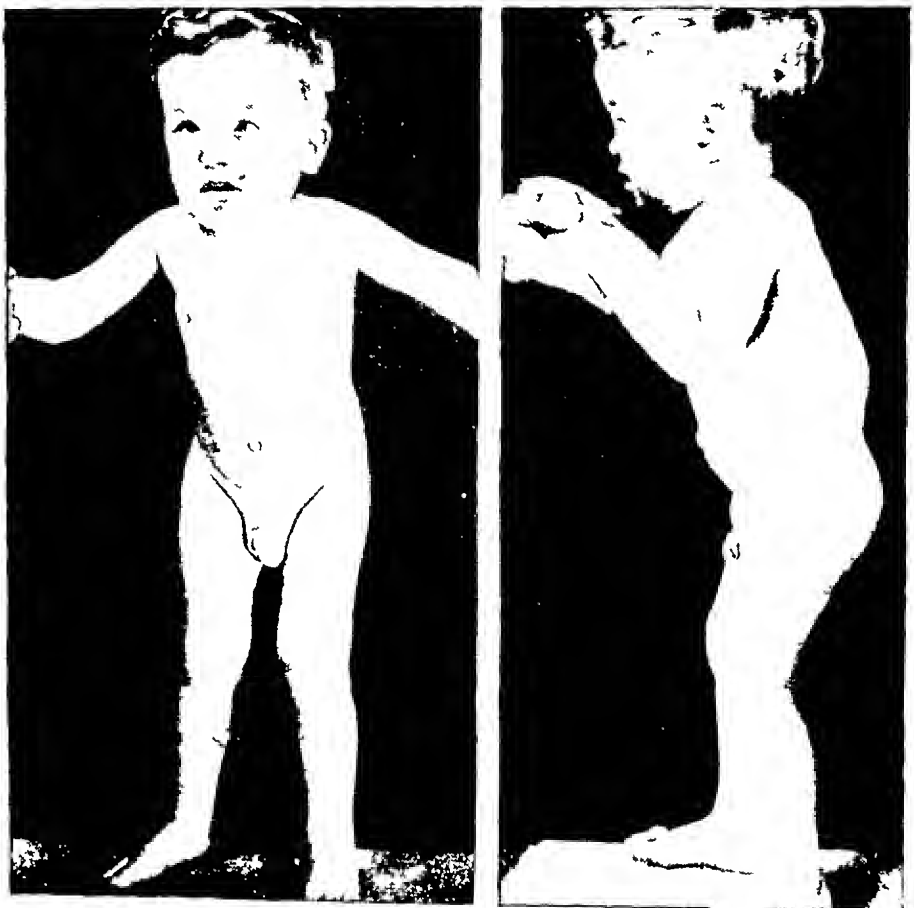

Fig 39

Case 14 Photographs showing the large head and typical heavy features Note the typical attitude on standing with the hips and knees flexed and the lumbar kyphosis

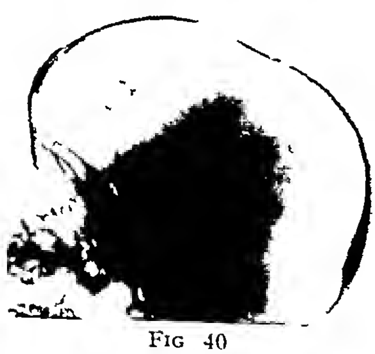

Fig 40

Fig 41

Case 14 Showing enlargement of the sella turcica (Fig 40) and enlarged acetabula poorly formed roofs and a mild degree of coxa valga (Fig 41)

FIG 42

FIG 43

Case 14 Lateral radiograph of the spine (Fig 42) showing the apex of the kyphosis formed by the second lumbar body which is small (D 12 is without corresponding ribs) The bodies of the second and third lumbar vertebrae show a beaked shape There is some enlargement of the anterior parts of the ribs Lateral radiographs of the spine taken in flexion (Fig 43) show that there is much greater forward movement of the first lumbar vertebra, occurring at the intervertebral joint between it and the small displaced second lumbar body than at any other level of the spine

CASE 15—GARGOYLISM

(Figs 44–47) Male, aged three years Mentally backward Corneae cloudy Facies coarse and heavy Head large, bossing above ears, eyes widely separated, bridge of nose broad, teeth spaced, hair coarse, eyebrows thick Liver and spleen enlarged Nasal discharge Unable to sit up Well-defined angular kyphosis in upper lumbar region Some scoliosis Limitation of movement of the elbows Radiographs coxa valga, femoral necks long, acetabular roofs sloping, skull large, pituitary fossa enlarged antero-posteriorly, no sign of erosion, second lumbar body rather small, of typical shape, and slightly displaced backwards, other bodies biconvex Biochemical investigations revealed nothing of importance (Under Dr Wilfred Sheldon)

Fig 44

Fig 45

Case 15 Lateral radiograph of the skull (Fig 44) shows the abnormal size of the sella turcica which has a smooth sharply defined outline Radiograph of the hand (Fig 45) shows the abnormal shape and texture of the bones The bases of the metacarpals are somewhat pointed The radius and ulna are thick and the lower ends of their shafts deformed

Fig 46

Fig. 47

Case 15 The roof of the acetabulum is poorly formed on both sides and the femoral heads lie a little high (Fig 46) There is bilateral coxa valga and the femoral necks are of unusual length Radiograph of the spine (Fig 47) shows an angular deformity with the apex at the second lumbar vertebra the body of which is small beaked and displaced a little backward The other vertebral bodies are biconvex and not flattened

CASE 16—GARGOYLISM

(Figs 48–51) Male, aged nine years Mentally backward but talkative and observant Walked at the age of one year Noticed to be clumsy with his hands at the age of two years Definitely dwarfed Head not unduly large One eye removed for glioma of retina Spleen just palpable, liver not enlarged Some limitation of movement of the shoulder, elbow, hip and knee joints Fingers short and stubby, joints thick, extension limited The three inner fingers curve towards the first Bones of the arms, forearms, and wrists feel thicker than normal Radiographs sella small, long bones thickened, coxa valga, acetabula of better shape than usual, spine typical *Blood examination* nothing of significance He the seventh of a family of seven, the eldest being twenty-eight (Under Dr E A Cockayne)

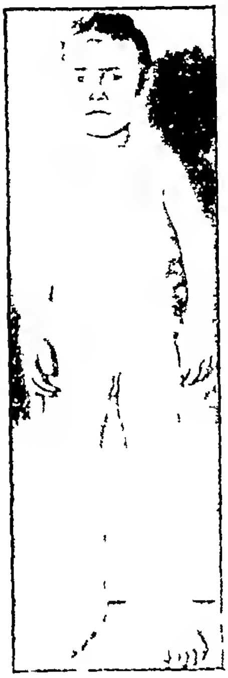

Fig 48

Fig 49

Figs 48–49

Case 16 Photograph of the child at the age of nine years (Fig 48) shows that the face is by no means typical The arms are rather short Radiographs of th skull showed a small sella turcica and no signs of frontal sinuses which should be visible at th age The spine (Fig 49) show biconvex bodies the second lumbar being rather small and of typical beaked shape a suspicion of a similar shape is seen in the third and fourth lumbar bodies

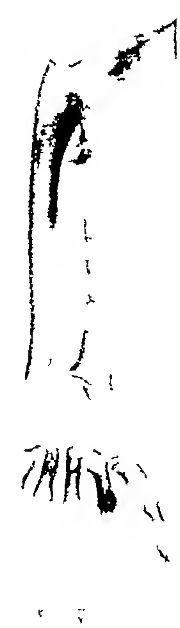

Fig 50

Fig 51

Figs 50–51

Case 16 The right forearm (Fig 50) shows stout bones impaired ossification of the lower radial and ulnar epiphyses and of the carpus and abnormal shape and texture of the bones of the hand Note the tilting of the lower ends of the radiu and ulna The femora show unusual thickness (Fig 51) The symmetrical thickening of the lateral cortex is curious but is no regarded as significant, simil thickening has been seen in a case of chondro-osteo dystrophy of the Morquio Brailsford typ

AN ANCIENT EGYPTIAN TREATISE ON TRAUMATOLOGY 2800 B C

M Kamel Hussein, Cairo, Egypt

Among the hundred thousand labourers who, according to Herodotus, were engaged for thirty years on the construction of the Great Pyramid, cutting huge stones, transporting them over land and water, and lifting them to great heights, serious accidents must have occurred almost daily Priests visited the victims as part of their duty, read sacred incantations and administered herbs, but in general left them to the care of the gods One of the labourers, however, was specially interested he watched them carefully, examined them repeatedly, and helped them so far as he could with his meagre knowledge He was an illiterate farmer with no pretence to any of the forms of education that were accepted in his day He was innocent of exalted priestly knowledge and had no inkling of the vast information acquired by the domineering scribes, but it was this very ignorance that saved his mind from the doctrines, dogmas, hymns and charms of the highly educated, and his virgin mind was thus given full scope to develop its powers This natural development proved to be exactly along the lines now recognised by modern medicine He examined patients, acquired a vast experience, and remembered his clinical observations Without the aid of records or any method of statistical analysis he grouped cases into clinical entities, foretold prognosis, treated patients rationally, examined them again and again, and observed the development of their diseases until they died or recovered This was quite different from the technique of Hippocratic medicine, or Greek natural philosophy, which consisted in building logically and by deduction a great superstructure of knowledge on the basis of flimsy evidence and unimportant observation His work proved that the inductive method can develop naturally even in the untutored mind and that human culture need not have waited so long before adopting it as the correct technique of thinking

It is true that this doctor of ancient Egypt did not create a school His work was too advanced for the age in which it was produced It could not have been considered high culture—such a distinction was reserved for metaphysics, the occult arts and magic, which did little to permit the growth of inductive reasoning Yet his work must have been appreciated by his contemporaries who became aware of its importance and asked him to commit his experience to writing I imagine him as a grey haired man, who had seen the Great Pyramid grow, had seen some patients die and others recover, and thereafter told his younger colleagues what would happen to their patients Almost invariably it befell as he told, and they marvelled They were filled with admiration and wrote down the sayings of their great Master He dictated his treatise—the first medical treatise in history It was sought eagerly and commentated carefully About one thousand years later, during the 17th century B C, one copy, which unfortunately was unfinished, appears to have been mistaken for part of the Book of the Dead and was buried in a grave where it remained for about thirty-five centuries In 1862 it was bought by an American Egyptologist, Edwin Smith, and later it was studied by Professor Breasted, the celebrated Egyptologist

The style is remarkable There is a peculiar quality, common to all original thinking, in which first-hand knowledge seems to be expressed so naturally It is concise, unpretentious, orderly and simple To find the same style we must pass through the centuries to the pages of "De Motu Cordis" Ambroise Pare described fracture of the spine with paraplegia in the same graphic and succinct manner as this Egyptian author (Brockbank and Griffiths 1948) *

* Brockbank W and Griffiths D Ll (1948) Journal of Bone and Joint Surgery, 30-B 556

His talent for classification and orderly exposition is obvious He was the first to use terminology which would not be intelligible to laymen and which had to be explained

The papyrus itself, which has come to be known as the Edwin Smith Papyrus, is a collection of clinical records (forty-eight in all) They are arranged in logical fashion, starting with injuries of the head, and then the face, temporal region, mandible, chin, cervical vertebrae, clavicle, humerus and sternum In each group he begins with the simple, superficial and less dangerous injuries and then discusses deeper and more serious disorders Reports of the eight cases of head injury began by describing wounds of the scalp In a glossary the word " examine " is explained as having some relation to counting the pulse, " to know the action of the heart from which vessels go to every limb, hands, and feet " The commentator adds " a priest of Sekhmat or any other physician puts his hands or fingers upon head or hands and measures the heart " This knowledge of the pulse, and its clinical use as a measure of the action of the heart, was not known to Hippocrates and became

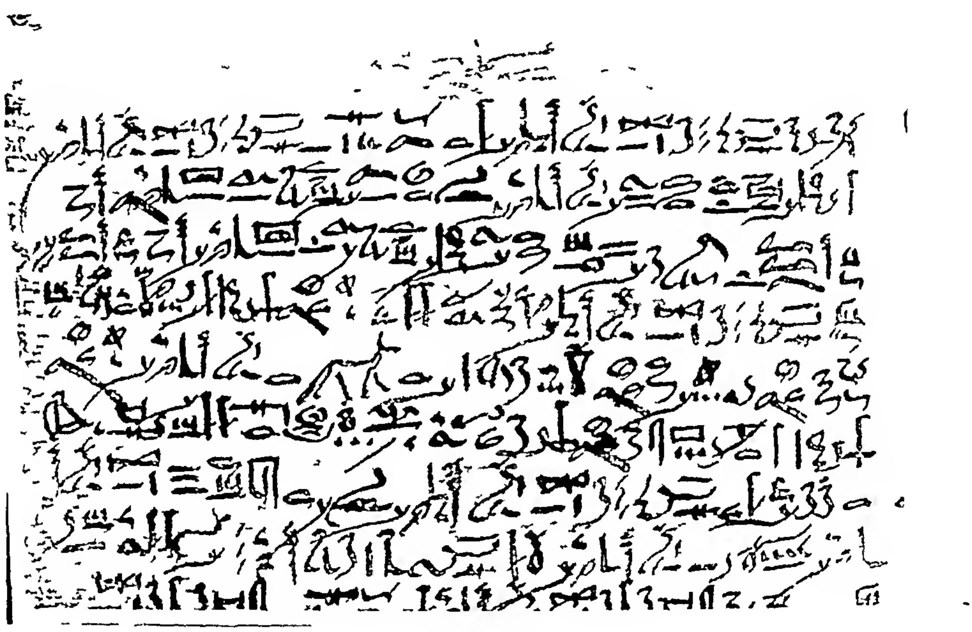

FIG 1

Facsimile of the original hieroglyphic text of Case 6

popular only through the work of the doctors of Alexandria Case 3 is one of compound fracture of the vault of the skull and in it he advises digital examination of the wound Case 4 is the first of the more serious cases where the examination discloses " something disturbing under the finger " In spite of bleeding from the nostrils and ears, and stiffness of the neck, the verdict is given as " an ailment with which I shall contend " Case 5 differ from this only in so far as there is depression of the fracture but the verdict is " an ailment not to be treated "

In describing Case 6 it is recorded " If thou examinest a man having a gaping wound in his head, penetrating to the bone, smashing his skull, and rending open the brain of his skull, thou shouldst palpate his wound Shouldst thou find that smash which is in his skull like those corrugations which form in molten copper, and something therein throbbing and fluttering under thy fingers, like the weak place of an infant's crown before it becomes whole when it has happened there is no throbbing and fluttering under thy fingers until the brain

of his skull is rent open, he discharges blood from both nostrils, he suffers from stiffness of his neck, thou shouldst say an ailment not to be treated Thou shouldst anoint his wound with grease Thou shalt not bind it, thou shalt not apply two strips upon it, until thou knowest that he reached a decisive point " Fig 1 is a facsimile of the original hieroglyphic of this case Here is mentioned for the first time in history the brain The gyri are compared to molten copper Pulsations are observed and their absence is recognised as a serious sign The case is evidently one of compression of the brain after a fractured base of the skull The glossary of this case explains that the membranes are ruptured and that " it breaks open his fluid in the interior of his skull " He does not say blood and this could mean only cerebro-spinal fluid

Case 7 is probably one of meningitis and is a little puzzling Case 8, on the contrary, is beautifully clear " If thou examinest a man having smash of his skull under skin of his head, palpate his wound Shouldst thou find that there is swelling protruding on the outside of that smash which is in his skull, his eye is askew because of it on the side of him having that injury which is in his skull, and he walks shuffling with his sole on the side of the injury—thou shouldst recognise him as one whom something has smitten from outside as one who does not release his shoulder fork and who does not fall with the finger nails in the middle of his palm He suffers from stiffness of neck and bleeds from ears and nostrils An ailment not to be treated Sit him up till he regains colour and until he reaches a decisive point " A second examination records observations exactly as Case 6 as far as the words " an ailment not to be treated " This is a clear case of hemiplegia after head injury with conjugate deviation of the eyes For once he changes the formula " thou shalt say concerning him " and writes " thou shouldst recognise him as one whom something from outside has smitten " I believe this shows that he wanted to make a distinction between hemiplegia due to internal disease and that due to injury

Let us compare the observations of this Egyptian doctor on head injuries with those made about 2500 years later by Hippocrates who is acknowledged as one of the world's greatest medical thinkers Hippocrates first noted that the configuration of the skull and the arrangement of sutures differed in various parts and said " the region which is thinnest and weakest is the forehead There the skull has least flesh over it and most brain matter underneath " From this it was assumed, by logic and not from clinical observation, that " the bone is more likely to be contused, fractured, and depressed and these lesions are more dangerous, more difficult to treat and less likely to escape death than lesions in other regions, and when death occurs it occurs earlier, for the brain suffers more seeing that the bone is thinnest and brain matter thickest there " The theme was developed and lesions caused by different weapons in different regions of the skull were considered, many conclusions being derived from the not very significant fact that the skull was thinnest in the forehead The rest followed This was real Greek logic and quite foreign to our author There is much sound observation in the Hippocratic thesis, and in his writings the operative procedure of trephining is well discussed But one does not gain the impression of clear recognition of clinical details of individual cases, nor of the fundamental facts of head injuries The characteristic features of fracture of the base, compression of the brain, meningitis, and conjugate deviation of the eyes, were never impressed upon him by direct observation, and the undue attention he paid to the fracture itself influenced surgical text-books until very recent times It is the brain injury that matters—not the fractured skull, and this was the emphasis of our very ancient author His observations lay much nearer to the truth than many of those of Greek medicine which captured imagination by their cleverness rather than their soundness

The Egyptian papyrus, Case 20, a wound of the temporal region, mentions bleeding from the nostrils and both eyes and adds that the " patient wipes his eyes with the back of his hand like a child and knows not that he does so "—a beautiful description of cerebral

irritation Fracture of the mandible with fever is pronounced an ailment not to be treated The report of Case 25 is a gem "If thou examinest a man having dislocation of his mandible and the mouth is open, thou shouldst put thy thumb upon the end of the rami of his mandible and your two claws (hands) under his chin and thus reduce his dislocation" There never was, and probably never will be, another method of reduction for this dislocation!

In the management of injuries of the spine, Case 31 is a typical record It is entitled "Instructions concerning a dislocation in a vertebra of his neck" "If thou examinest a man having a dislocation of a vertebra of his neck, shouldst thou find him unconscious of his two arms and his two legs on account of it, while his phallus is erected on account of it and urine drops from his member without his knowing it, his flesh has received wind, his two eyes are bloodshot, it is a dislocation of a vertebra of his neck extending to his back-bone which causes him to be unconscious of his two arms and two legs If, however, the middle vertebra of his neck is dislocated, it is an emissio seminis which befalls his phallus (it remains stationary, when it cannot sink downwards, it cannot lift upwards) *Diagnosis* Thou shouldst say concerning him One having a dislocation in a vertebra of his neck, while he is unconscious of his two legs and his two arms, and his urine dribbles, an ailment not to be treated"

In the treatment of fractures of the clavicle it is recorded that the patient should be placed "prostrate on his back with something folded between his shoulder blades with his two shoulders to stretch apart his collar bone until the break falls in its place Place two splints of linen, one on the inside and the other on the underside of his arm" Has any material progress been made in the treatment of this injury in the fifty centuries that have since elapsed?

There seems little doubt that the author of this papyrus was skilled not only in clinical observation but also in anatomical dissection and post-mortem examination apart, I think from embalming How else would he have known of the meninges of the brain, and the likeness of the gyri of the brain to molten copper? How otherwise could he have referred to "canals leading from the heart to every member," and to the "two canals on each side of the throat leading into the lungs?" Would clinical observation alone have shown him that in fractures of the spine the crushing of one vertebra into another was "like the imprint of a foot in cultivated ground?"

His knowledge of physiology and pathology was of course limited but he knew that by feeling the pulse he could assess the action of the heart, and that injuries of the brain could cause paralysis of the opposite side of the trunk and limbs He knew something of conjugate deviation of the eyes He knew about inflammation and described the signs of redness, swelling and heat He recognised the danger of fever in a compound fracture He described a sprain as "a rending of two members though each is still in its place" He knew that compression of the brain was dangerous when pulsation of the brain ceased And we should perhaps emphasize the eagerness with which in Case 8, an injury of the skull and brain, he claimed that symptoms were caused by "something from outside smiting him"—thus denying the supernatural and demoniacal influences of a fall which even to this day, more than five thousand years later, are held in certain parts of Egypt

The author lived 2800 years before Christ, he saw the building of the Pyramids, he had powers of clinical observation even greater than those of Hippocrates, and he recorded methods of treatment which have not been excelled to-day His work was indeed too advanced for the age in which he lived

ORTHOPAEDIC SURGERY IN THE SIXTEENTH AND SEVENTEENTH CENTURIES

TRACTION APPARATUS—THE VIDIAN PICTURES

D Ll Griffiths and William Brockbank

From the Medical Library of the University of Manchester

The story of traction apparatus in the sixteenth and seventeenth centuries is part of the story of the effect of the Renaissance and of the rediscovery of Greek texts Traction, more or less in the long axis of the limb, had been the classical method of reducing fractures since early antiquity Hippocrates gave an account, as surprisingly modern as is so much of his work, of its dangers and its limitations But Hippocratic appliances for producing powerful traction appear to have dropped out of use in the general decline of learning which followed the fall of Rome Guy de Chauliac (1300–1368) is credited with the introduction of continuous traction with a weight and a pulley for the treatment of fractures of the femur, but very little else is known about pre-Renaissance traction appliances

Greek learning lasted longer in Byzantium than in Western Europe Somewhere about A D 900 a Byzantine physician named Niketas made a collection of surgical manuscripts which included a series of full-size plates illustrating the treatise of Hippocrates on dislocations The illustrations represented Byzantine practice but their genuineness is accepted The manuscripts, with the illustrations, were bought in Crete in 1495 by an agent for Lorenzo de Medici and were reproduced by two Renaissance artists, one of whom was Primaticcio These reproductions were in turn used by Guido Guidi (1500?–1569) to illustrate his collection of translations of surgical papers which he published in 1544 in Paris by permission of " the Pope, the King of France, and the Duke of Ferrara " Guidi, whose Latinised name, Vidius, is commemorated by his discovery of the Vidian nerve, was an anatomist-surgeon One of the teachers of Vesalius, he was a supporter of Hippocratic principles and an antagonist of those who believed that blood passed from the right heart to the left directly through pores in the septum He also gave a description of syphilitic caries of the skull that was probably the first of its kind (Mettler)

Guidi's " Chirurgia e Graeco in Latinum conversa " is a series of translations of Greek authors into Renaissance Latin with a certain amount of original commentary The text of the orthopaedic sections is very second-hand There is no direct translation of an original author in the sections on fractures, on joints, or on dislocations Instead, these chapters are renderings into Latin of commentaries on the original Greek authors, such as Galen's commentary on Hippocrates' account of fractures, and the commentary of Oribasius on Heliodorus's description of surgical appliances Oribasius (A D 325–405) was a Byzantine, a compiler rather than an original author, whose compilations saved many works from loss Heliodorus lived probably just before Celsus in the first century and is mentioned by the poet Juvenal It was in the chapters on Heliodorus's work that the Primaticcio illustrations appear

The simplest of the traction devices shown in these pictures certainly existed before Hippocrates, for it consisted simply of levers used singly or in pairs (Fig 1) Windlasses were advocated to give even more powerful traction (Fig 2) A combination of windlasses and pulleys provided the traction force in the " Glossocomium " (Fig 3) This is perhaps the oldest fracture-apparatus of all The name is interesting, for though the Greek lexicon (Liddell and Scott) gives its Galenical use as " a surgical instrument for reducing fractures and dislocations," the word also means a case in which to keep the reeds and tongues of musical instruments, and in the New Testament it is used to mean a coffin

A Trabecula
B Ligna recuruata
C Lora.

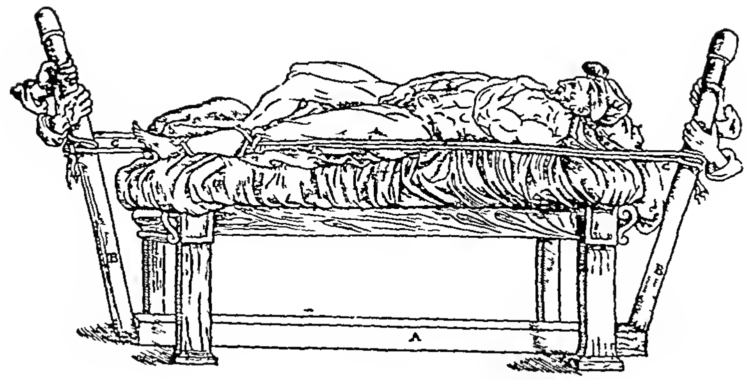

FIG 1

Traction on a fracture of the lower leg by means of two levers (Vidius) This is illustrated in the chapter dealing with Galen's commentary on Hippocrates work on fractures The 'traction tapes' (lora) were leather thongs—Hippocrates recommended ox-hide

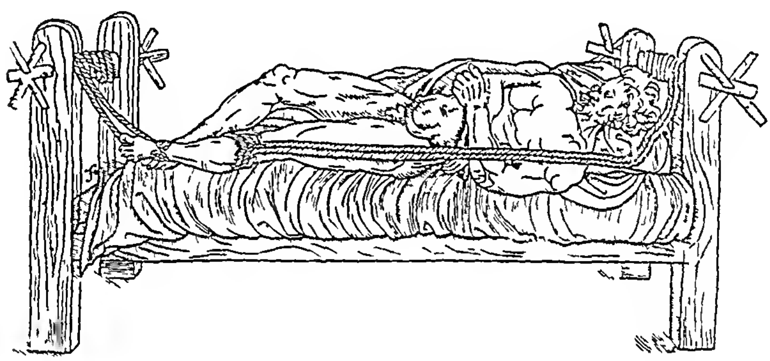

FIG 2

Simple windlasses replace the levers in this diagram in the same section of Vidius s book

GLOSSOCOMIVM
A Axis ad quem laquei alligantur
B Laqueus ſuperior
C Laqueus inferior
D Inferior pars gloſſocomij
E Trochleæ
F Superioris laquei capita ab exteriori parte gloſſocomij

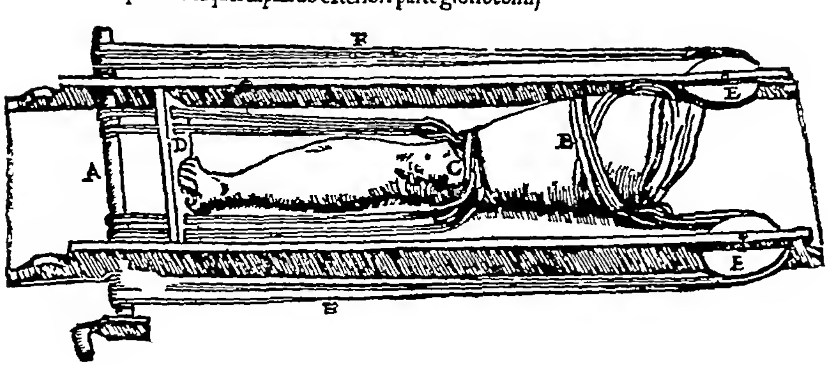

FIG 3

The Glossocomium This illustration of the appliance comes from the 1625 edition of Galen Vidius has a diagram with identical explanatory notes and lettering but his more beautiful drawing is less clear

The Oribasius-Heliodorus section of the book illustrates several much more complicated machines including an upper limb appliance (Figs 4 and 5) But the most famous of all the appliances illustrated by *Vidius is the Hippocratic Scamnum* (Fig 7) This device, about which there has been some controversy, and which in its Vidian form may have derived as much from the mediaeval rack as from the Greek scamnum, could be used for the reduction of almost any fracture or dislocation We have already illustrated examples of its application to injuries of the shoulder and the spine in earlier numbers of this series of annotations and

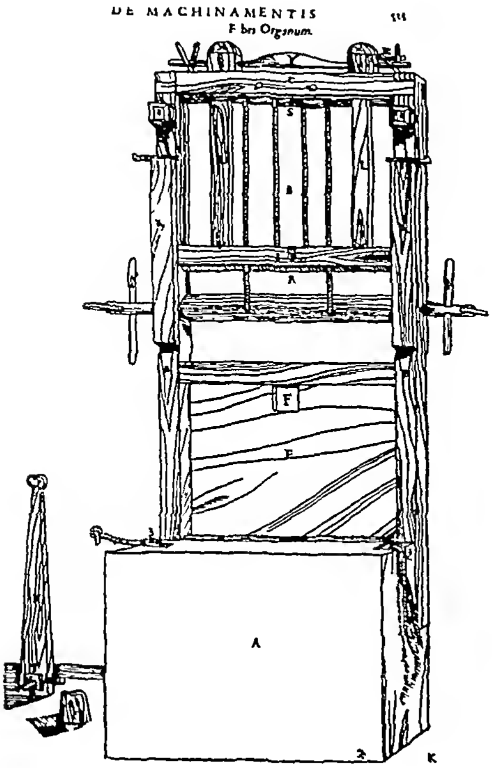

FIG 4

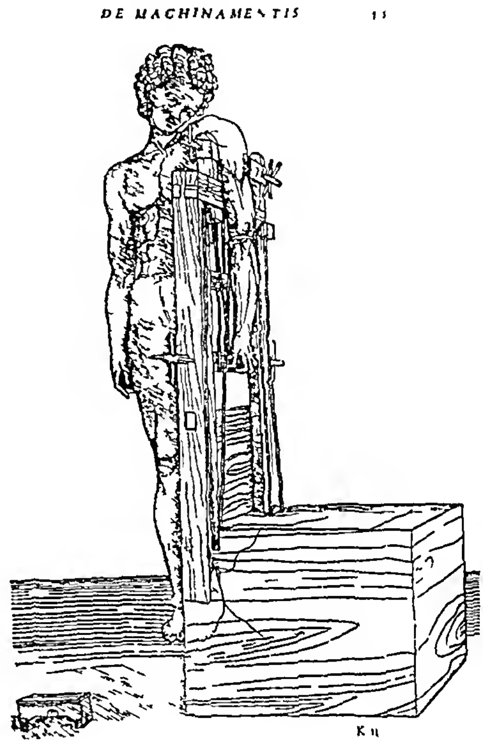

FIG 5

A traction apparatus for the upper limb illustrated by Vidius in the translation of Oribasius's commentary on Heliodorus on surgical instruments (Fig 4) The apparatus is shown in use for a fracture of the upper limbs in Fig 5

it is shown here in the treatment of a fracture of the mandible (Fig 8) This versatile appliance appears to have remained constantly in use, well into the eighteenth century Fig 6 shows the reduction of a fracture of the leg by means of the *Scamnum*, in the time of Johann Schultes (Scultetus, 1595–1645) one hundred years after Vidius

The Greek, mediaeval and Renaissance interest in more and more powerful traction reflects the contemporary ignorance of direct manipulation as a means of reducing fractures In view of the early use of manipulation in dislocations this is a little odd, but reduction of

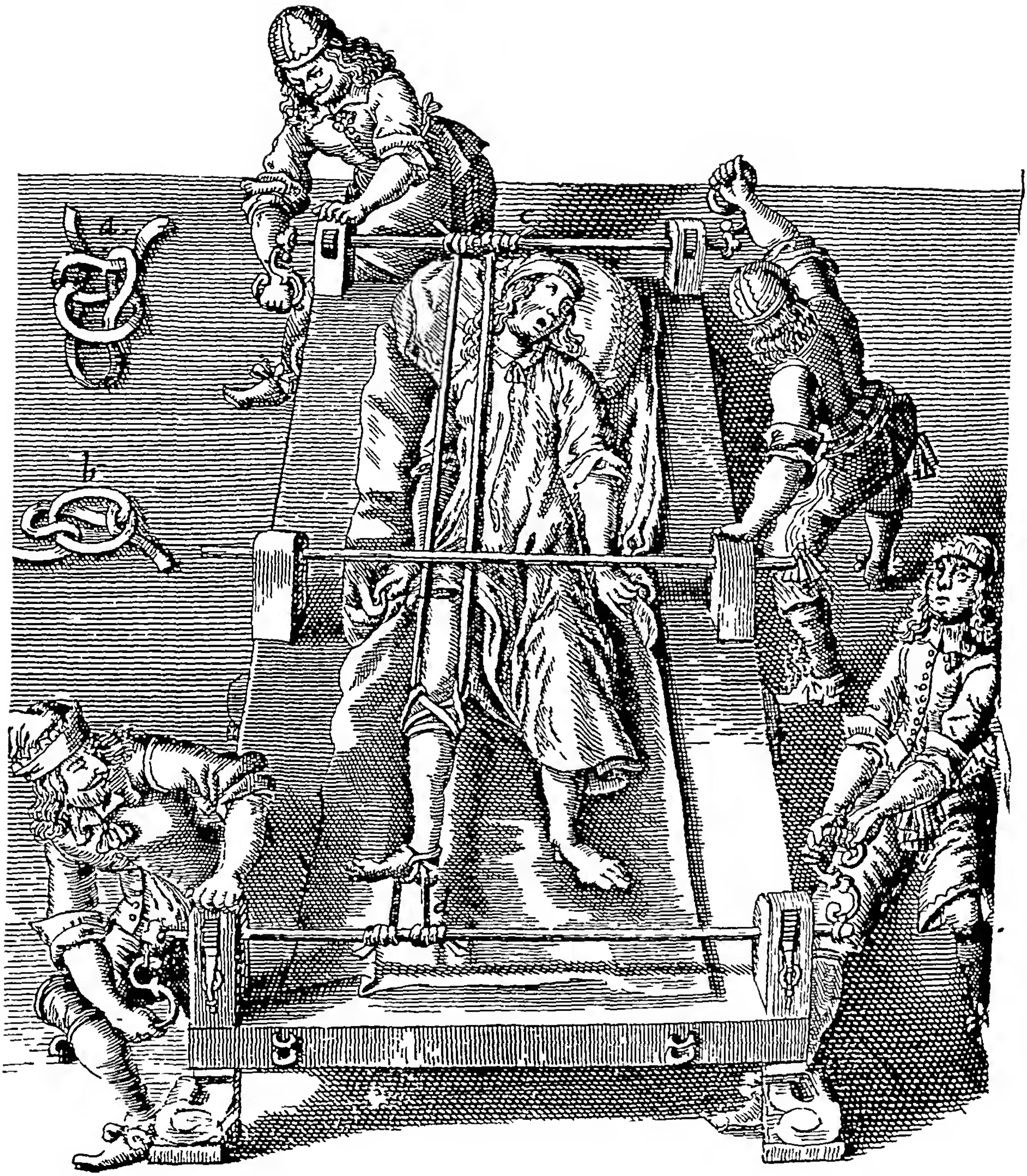

FIG 6

The Scamnum in use in the seventeenth century (Scultetus) This is the Vidian reconstruction *without the modifications suggested by Littre*

fractures by anything other than traction appears to have been unknown until almost the nineteenth century The fracture appliances of later writers in the sixteenth and seventeenth centuries, such as Pare, Fabry and Schultes, show no more than increasingly powerful machines, leading ultimately to the use of block and tackle and screw-traction appliances such as we previously illustrated in use for dislocations of the shoulder

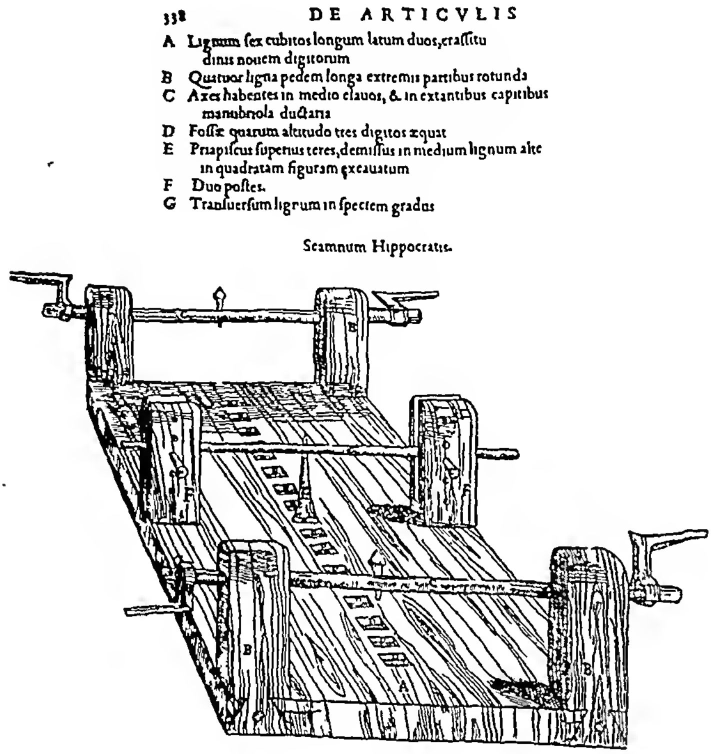

Fig 7

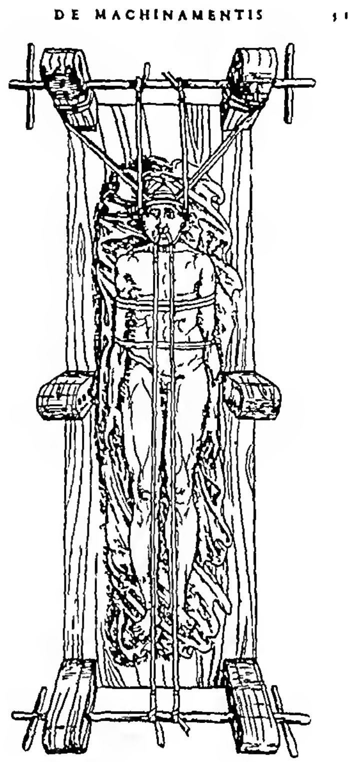

Fig 8

The Scamnum of Hippocrates This was recommended by its originator (On Joints LXXII) as worth while obtaining by anyone practising surgery in a populous city It is considered that Vidius s illustration (shown twice in his book) may err in showing square holes (D) down the middle These should perhaps have been a series of deep parallel grooves for a perineal centre post (E) which should be shorter and less pointed The corner posts (B) are possibly also too high (Littre) The intermediate supports (F) may originally have been movable One specimen of the Scamnum which is still in existence is however of the Vidian type Fig 8 shows the Scamnum in use for a mandibular fracture (Vidius)

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Book Reviews

OSTEOARTHRITIS OF THE HIP JOINT By H Warren CROWE D M, B Ch (Oxon) Senio Physician, Charterhouse Rheumatism Clinic $10 \times 7\frac{1}{2}$ in Pp viii+70 with 60 figures Index 194 London The Rolls House Publishing Co, Ltd Price 35/6

The reader who is attracted by the title of this book and expects to find a comprehensive review o so important a subject will be disappointed for the author sets out to do little more than present his own particular doctrines The thesis is, that in osteoarthritis "degeneration is not the main etiologic factor' that 'relief of pain should never be the primary object of therapy but rather the arrest of the pathologic process together with measures of rehabilitation,' and finally that "in the majority of even quite seve cases the prognosis is by no means unfavourable" The etiological hypothesis that is advanced ' that of an infection by commensal organisms following slight trauma" and it is claimed that "once th methods here advocated become generally used, the surgeon will no longer have to operate"

The basis upon which the book has been written comprises 500 cases treated since 1927 Yet the whole foundation of the evidence that might have been provided by such a large series is shaken at th very beginning by the statement that 'all forms of rheumatic arthritis at whatever age' are included Statistically therefore this book is valueless as a discussion of a particular entity The author regards clinical results as "always suspect' because they may be biased ' through enthusiasm" On the othe hand ' evidence of arrest of the disease as shown by skiagrams cannot be denied even by the most sceptical The author gives a table of twenty-three cases demonstrating radiographic evidence of ' complete arre t of the disease' "These' he says 'are not exceptional, but typical of from 70 to 80 per cent of all cases And yet elsewhere a table of clinical results in 263 cases shows only 56 5 per cent of good results It is not stated for how many years these cases have been studied, yet it is significant that the author is prepared to pass judgment on radiographic evidence of complete arrest after only one year in seven of twenty thre cases specially selected for illustration This is quite apart from the fact that no allowance is made for technical variations of radiography and photography

The treatments that Dr Warren Crowe is concerned to advance are vaccine therapy, intra articular injections, gymnastics, special appliances to stretch hips in abduction, and Taverner s denervation operation Mr Whitchurch Howell has been allowed less than one page to discuss the surgery of osteoarthriti Dr Crowe is a sincere person and because of his large experience he commands respect but his ca gains poor service from an enthusiasm that is not supported by clear and concise reporting with reasona judgment of the evidence —Norman CAPENER

THE MEDICAL ANNUAL 1948 Edited by Sir Henry TIDY K B E M D, F R C P and A Rendle SHORT M D F R C S with forty-two contributors Sixty-sixth Year $9 \times 6\frac{1}{2}$ in Pp lxxvi+414 with 59 figures Index 1948 Bristol John Wright & Sons Ltd London Simpkin Marshall (1941) Ltd Baltimore The Williams & Wilkins Company Toronto The Macmillan Co of Canada, Ltd Melbourne W Ramsay Sydney Angus & Robertson, Ltd Price 25/–

This well-known publication is arranged along the same lines as in previous years The relatively few items on orthopaedic subjects that are included in the present volume will be of interest to the general practitioner rather than to the specialist Orthopaedic surgeons will find that the reviews and extracts are insufficiently detailed to be of practical value and in *many* cases they will already have read the original contribution itself But even if this is so they will be reminded of their earlier reading and moreover, they will be offered in concise form a means of keeping abreast of modern progress in fields of medicine and surgery other than their own This is a book which every specialist might read with benefit

The main sections of orthopaedic interest are those concerned with poliomyelitis, arthritis bicep reconstruction epiphysial disorders, cervical rib, anticoagulant drugs and streptomycin In general th selection of material is representative and the reviewers' comments are fair This is true particularly c the section on poliomyelitis, an important topic in view of the unprecedented extent of the 1947 epidem in Great Britain and of the changes that appear to be taking place in the characteristics of this disea The inclusion of a section on cervical rib and costo-clavicular compression and of Sir Thomas Fairbank work on epiphysial disorders is also timely The reviewer does well to emphasize that there are caus of sciatica other than prolapse of an intervertebral disc It is doubtful however whether the report two patients treated by division of the pyriformis will carry any conviction that abnormalities of th muscle play an important part The discussion on the anticoagulants, heparin and dicoumarol and c streptomycin, places the use of these drugs in their proper perspective The necessity for adequate contro during administration is rightly emphasized —H OSMOND-CLARKE

ACIK KIRIKLAR VE KOMPLIKASYONLARI TESHIS VE TEDAVILERI (THE DIAGNOSIS AND TREATMENT OF OPEN BONE FRACTURES AND THEIR COMPLICATIONS) By Dervis MANIZADE 9¾×7 in Pp xv+244 with 89 figures, four in colour 1948 Istanbul Kenan Matbaası Paper cover

We review here the thirty-page summary written in excellent English, which concludes this monograph epitomising modern practice in the treatment of open fractures The work contains little that is new but it is well arranged and clearly written The clinical classification is good and there is special emphasis on the treatment of the whole patient and particularly the treatment of shock and such complications as fat embolism James Latta s original description of shock in 1795 is quoted as " collapse of blood circulation caused by severe injury ' a remarkably brief and correct summing up of a condition that almost defies definition Local anaesthesia with little or no adrenalin is used most frequently Wide excision of the wound is insisted upon with avoidance of the insertion of foreign bodies even ligatures so far as they can be avoided Scarcity of penicillin in Turkey has obliged the author to supplement his limited experience of its use by the results of others Wounds are preferably left exposed and the limb is elevated In relieving pain the author rightly insists upon the avoidance of technical faults such as unsuitable posture of the limb, but he is perhaps too unwilling to make use of analgesics He stresses the importance of minerals and vitamins in the diet but makes no mention of other factors such as proteins which are of great importance in the injured This work comes from the *First Surgical Clinic of the* University of Istanbul We should like to see more surgical material from Turkey, with good English summaries as in the present instance because it would help us to keep in touch with the work of our friends in that country —H Jackson BURROWS

A SYNOPSIS OF ORTHOPAEDIC SURGERY By A David LE VAY M S F R C S, Honorary Orthopaedic Surgeon Woolwich Memorial Hospital 9×7 in Pp vii+242 with 55 figures Index 1947 London H K Lewis & Co Ltd Price 15/-

This little book as Le Vay describes it will not prove of great interest to readers of the Journal of Bone and Joint Surgery It is intended to be no more than a ' concise factual survey of orthopaedic surgery for the use of senior undergraduates and possibly of post-graduate students working for higher qualifications We may all regard ourselves as ' senior undergraduates, but it is likely that we shall be more attracted to reading in the wider fields of those authorities to whom Le Vay pays acknowledgment

The post-graduate working for a higher qualification in surgery may find this book useful in the final frantic hours before the day of examination but it will not gain for him a sound and balanced appreciation of orthopaedic surgery It has always been difficult to define " orthopaedics and it has often been impossible to limit the field of orthopaedic surgery but surely we are concerned with a special craftsmanship dealing with various pathological conditions that affect the locomotor system Le Vay assumes in his reader a knowledge of the principles of orthopaedic treatment which the student does not possess A good deal of the space that he devotes to descriptive pathology and differential diagnosis could better be used for subjects he omits for instance some discussion of the types of deformity and the reasons why they arise the principles of splinting including the use of appliances and plaster-of-Paris and the principles of physiotherapy especially muscle re-education in all its aspects There is no composite description or discussion of such common orthopaedic procedures as tendon transplantation osteotomy or arthrodesis There is no section at all on the use of bone as a graft

Those of us who are concerned with teaching are often asked to recommend a short descriptive work on orthopaedic surgery Le Vay is to be congratulated on his attempt to satisfy the needs of the student but unfortunately he has not wholly achieved his aim —W D COLTART

Editorial note—In British numbers of the Journal of Bone and Joint Surgery no reviews of books are published under the cloak of anonymity and honesty of opinion is assured thereby But it would be curious if there was never difference of opinion The opinion of at least two members of the Editorial Board as to the merit of Le Vay s Synopsis of Orthopaedic Surgery appears to differ from that of Mr Coltart The comment of the sub editor is The Synopsis is remarkably up to date and comprehensive for its size and it will surely be of much value to students both undergraduate and post-graduate We trust therefore that Mr Le Vay will take note of our critical comments but will not be unduly discouraged

ANAESTHESIA FOR THE POOR RISK, and Other Essays By William W MUSHIN, M A (Oxon) M B F F A D A Director Department of Anaesthetics Welsh National School of Medicine, Cardiff formerly First Assistant Nuffield Department of Anaesthetics University of Oxford 8½×5½ in Pp ix+65 1948 Oxford Blackwell Scientific Publications Ltd Price 7/6 (This volume will be included as No 49 in the American Lecture Series)

This is a collection of twenty-eight essays on various subjects—mostly controversial—connected with anaesthesia The reader is unlikely to agree with all that the author says but he will appreciate the

arguments and will enjoy the attractive style of writing Many fallacies are exposed, such as the desirability of employing spinal block in shocked patients the belief that all anaesthetic convulsions are due to ether and the view that dissolving local analgesics in oil is a scientific way of prolonging their effect The book can be read through at one sitting and it is a welcome and unusual addition to the literature of anaesthetics —C Langton HEWER

LA DENUTRITION DE GUERRE ÉTUDE CLINIQUE, ANATOMO-PATHOLOGIQUE ET THERAPEUTIQUE By Ed F SIMONART $10\frac{1}{4} \times 7$ in Pp 262, with 40 figures 1948 Brussels Acta Medica Belgica Paris Maloine Paper cover

Simonart studied the effects of prolonged undernutrition on the inmates of a civil prison at Louvain during the German occupation of Belgium The daily ration was approximately 1400–1500 calories Fat and protein formed only a small part of the diet The main locomotor disturbances that he observed were muscular weakness and neurological disorders reminiscent of beri-beri He showed that the weakness of muscles was due in part to loss of muscle substance and in part to deficiency of vitamin B_1 muscle power was increased by the intravenous administration of this vitamin Biochemical evidence was obtained which supported his conclusion that deficiency of vitamin B_1 was the essential cause of the neurological findings It is surprising that in such a population he found no evidence of skeletal changes in similar patients other workers have shown radiographic evidence of osteoporosis (Brull, L, 1945 Les etats de carence en Belgique Liege Editions Soledi and Hottinger, A Gsell O Uehlinger E Salzman C and Labhart A 1948 Hungerkrankheit, hungerodem hungertuberkulose Basel Benno Schwabe & Co New York Grune & Stratton, Inc) Demineralisation in such cases was almost entirely confined to males over the age of fifty years —John BEATTIE

FRACTURES AND ORTHOPAEDIC SURGERY FOR NURSES AND MASSEUSES By Arthur NAYLOR, Ch M , M B , M Sc (Sheff) F R C S (Eng) F R C S (Edin) Honorary Orthopaedic Surgeon Bradford Royal Infirmary and Bradford Children's Hospital, Orthopaedic Surgeon Bradford Municipal General (St Luke s) Hospital and Bradford Education Committee Temp Major, Orthopaedic Specialist R A M C Second Edition $8\frac{3}{4} \times 5\frac{1}{2}$ in Pp xiv+296 with 251 figures Index 1948 Edinburgh E & S Livingstone Ltd Price 17/6

Specialisation in medicine and surgery is so well established in our age and indeed so essential that it is inevitable that it should permeate the professions of nursing and physiotherapy It is important therefore that specialist text-books for nurses and physiotherapists should be produced and so far as orthopaedic and traumatic surgery is concerned the author of this book has carried out his task well The second edition maintains its high standard, but it is a pity that in revising it the author did not take the opportunity to improve several illustrations particularly those of splints and indeed to eliminate some of the text describing them On page 21 the almost obsolete Thomas hip splint is reproduced as in text books and catalogues of the last century together with a half-page paragraph which is introduced by way of acknowledgment of its almost complete obsolescence Elsewhere, splints that are almost entirely discarded are illustrated by reproductions from instrument makers' catalogues The opportunity might also have been taken to bring the title up to date Apart from these criticisms, which are almost entirely confined to the descriptions of apparatus the book is of a high standard in both text and illustrations and it should be of value both to nurses and physiotherapists, particularly when taken in conjunction with their practical work —John A CHOLMELEY

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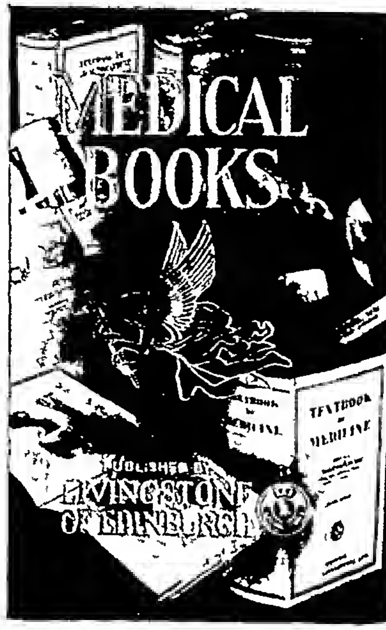

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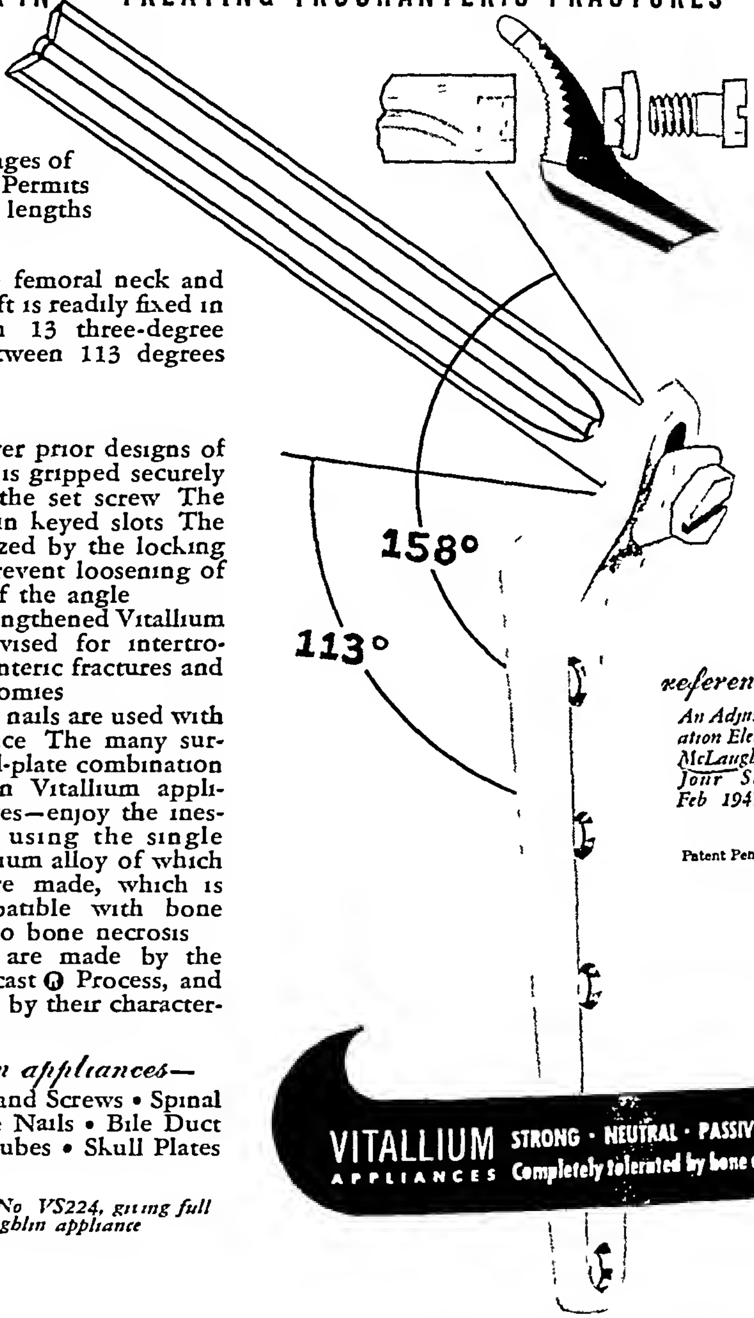

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The Journal of Bone and Joint Surgery

BRITISH VOLUME

INTERMITTENT CLAUDICATION

The association between lameness and arterial disease was recognised over a century ago and yet it is only within the past twenty years, since Lewis explained the pain of claudication, and sympathectomy was practised for its relief, that interest in the subject has grown sufficiently to make claudication in the calf a commonplace Even to-day, similar pain in the foot or buttock is mistaken too often for evidence of foot-strain or arthritis

Fuller understanding of muscle pain due to ischaemia might have been expected to lead naturally to rational therapy, but it has been general experience that the results of many orms of treatment which from time to time have been fashionable seem to be unpredictable The reason for this must be that our understanding is still far from complete, and the publication in this number of the Journal of investigations by Professor Boyd and his colleagues, which make a substantial contribution to our knowledge of this complex subject, is most welcome

It is important in the first place to correct the usual teaching that there are but two forms of obliterative arteritis—Buerger's disease and arteriosclerosis Though it is generally true that the pathology of arterial obstruction in youth is different from that in older people, appears that the degenerative changes that have long been regarded as characteristic of the period after forty years of age may also be encountered much earlier in life Injury to main arteries, especially to the popliteal artery at the level of the knee joint, is an etiological factor that has not been given the prominence it deserves

It is now many years since Professor Boyd laid stress upon the importance, in regard both to symptomatology and prognosis, of the level in the arterial tree at which obstruction has occurred The opportunity he has had in Manchester of observing large numbers of patients with claudication has served to amplify his earlier ideas and enable him to separate his cases into well-defined groups according to the nature and site of the arterial obstruction As we should expect, the prognosis of the disease, and the response to treatment, have varied considerably in the different groups Of equal importance, however, particularly in forecasting nd assessing the results of different forms of treatment, is the severity of the claudication Patients who are able to continue walking slowly after the onset of moderate pain, and in whom the discomfort then disappears or persists only as a tolerable ache, naturally do better han those who cannot bear the pain and are quite unable to continue walking until it passes off, thus being forced to stop after a comparatively short distance

The suggestion, which used to be so popular, that arterial spasm plays a prominent part ven in obliterative arteritis becomes steadily less acceptable as more facts about the anatomy and pathology of the circulation are brought to light Though the occurrence of spasm in rge arteries cannot be doubted, it would appear that changes in the peripheral pulses during and after exercise, and certainly the benefits of sympathectomy for obliterative arteritis, can be explained without postulating the presence or relief of arterial spasm

The decision to advise sympathectomy for claudication is often difficult, involving not only assessment of the condition of the vessels in the affected limb but also, as Boyd points

out, full consideration of the state of the heart, the blood and the lungs, the blood pressure the metabolism and the general nutrition It is here that the advice of a medical colleague is so valuable, and this is surely a field in which the best interests of the patient are served only by close collaboration of physician and surgeon

When sympathectomy is not indicated it is important to know what palliative measures are available, and the Neurovascular Clinic in Manchester is providing the means by which to assess the value of drugs and such surgical procedures as neurectomy and tenotomy Much has already been done, and in days to come we will look with confidence to the same source for further enlightenment

J PATERSON ROSS

FRACTURES OF THE SPINE

A most stimulating article in this number of the Journal, on fractures of the dorso lumbar spine, presents strong evidence in support of the thesis that functional results are seldom related to anatomical results and that often the best treatment is to ignore displacement, resist the temptation to immobilise the spine in plaster, and teach active exercises from the beginning It is suggested that reduction of displacement by hyperextension is not always possible—that when it is possible it cannot always be maintained—that when it can be maintained it makes little difference to the end-result—and that when it does make a difference to the end-result it is to the disadvantage of the patient With typical cogency and conviction Nicoll claims that the treatment of vertebral fractures by hyperextension and immobilisation in plaster is needless in some fractures, useless in others, and harmful in nearly all

Some of us were taught as students that patients with spinal fractures should be put to bed between sandbags and protected from every movement until a posterior support had been fitted Permanent disability was accepted as inevitable With such training it took courage to believe that complete recovery might be possible, and it was with triumph that we learned to reduce deformity by hyperextension, immobilise the spine in a plaster jacket, and institute early active exercise for the spinal musculature We believed that an important advance had been made—and perhaps it had But it is right that triumph should be short lived, and to-day we are told that it was not the manipulative reduction or the immobilisation in plaster that mattered—the significant advance was the early institution of active exercise We are urged to believe that many fractures of the spine are best treated by exercise alone

Nicoll's case is based on careful and detailed analysis of 166 fractures of the spine in miners, whose conditions of work are such that it must be acknowledged at once that a man who continues full work at the coal face for five years after injury has indeed made a good functional recovery Twenty-four miners made such recovery despite gross anatomical deformity, and the severity of deformity that is illustrated in these pages, and shown to be compatible with full work as an underground ripper, will no doubt open the eyes of many readers Does this imply that gross deformity is the ideal end-result of the treatment of fractures? On the contrary it indicates that many psychological as well as physical factors are concerned in the determination of function—a truth that is emphasised in the article on traumatic paraplegia by Guttmann, who shows that even agonizing pain of causalgic type after spinal injury is often relieved more successfully by the psychological measures of rehabilitation than by the physical measures of operative surgery To what extent therefore were Nicoll's results independent of the physical standards of his treatment and more dependent on the excellent rehabilitation service that is available to the miner in Great Britain? Is it possible, for instance, that rehabilitation was applied more successfully when no plaster jacket was used than when it was, thus giving an erroneous impression that the plaster itself was harmful? Willingness to return to work depends no less on the art

on the science of medicine and we are left wondering whether return to work at the coal face is really to be accepted as a precise scientific measure of physical recovery—a measure upon which many of Nicoll's conclusions are based

If return to full duty is indeed to be accepted as an estimate of the success of treatment we might quote figures from another service in which rehabilitation was developed to a very high standard but in which nearly every patient with fracture of the spine was also treated by reduction of the displacement and immobilisation in plaster * In one group of 1058 vertebral fractures, treated by many orthopaedic surgeons in the Royal Air Force, no less than 91 4 per cent returned to duty, including not only those who engaged in heroic action against the enemy but also those who accepted the daily toil of heavy engineering and other arduous ground duties Only 6 6 per cent were invalided It may be that these results could be improved upon—but not by very much It may be that some of the treatment was unnecessary, but it would be difficult to concede that any of it was harmful

The claim that it is unnecessary to reduce minor wedge compression of fractured vertebral bodies may possibly be right Certainly we learned during the recent war that in simple compression fractures of the upper dorsal vertebrae (which occurred with particular frequency in the Air Forces owing to the use of Sutton shoulder harness which raised the fulcrum of movement from the lumbar to the upper dorsal level) such reduction was impossible and good functional recovery could often, though not always, be gained by early hyper-extension exercise It may be that reduction of minor compression, which is impossible in dorsal fractures, is unnecessary in lumbar fractures—though this writer must admit that in the mobile lumbar region he would prefer not to accept as a very obvious potential source of pain the distortion or, at least, strain of interarticular joints that must surely be inevitable if compression of vertebral bodies is left unreduced

But it is one thing to claim that reduction is unnecessary and another to claim that it is harmful—as Nicoll does We are reminded of the dangers of oedema and spreading ecchymosis in muscle planes (as if this did not occur in every fracture), and of the ill-effects of muscle shortening due to immobilisation (as if this was not easily corrected by exercise) It is suggested by statistics and theories that in patients with dorso-lumbar fractures the persistence of lumbo-sacral pain after long-sitting is attributable to immobilisation in plaster, and on this is based the conclusion that immobilisation is harmful But one young pilot fractured his twelfth dorsal vertebra in a crash-landing in Belgium and within a few hours began a thousand-mile trek along the roads and ditches of France, and the mountain passes of the Pyrenees, before arriving four months later in England with one complaint alone—namely, lumbo-sacral pain after long-sitting We should hesitate before accepting this symptom as a complication of immobilisation in plaster!

The urge to abandon immobilisation in favour of early functional activity has recently been applied also to fractures of the calcaneus, the tibial tuberosity, the carpal scaphoid bone and the neck of the humerus And yet many of us are still seeing gross deformity of the foot necessitating late operative treatment which could have been prevented by early manipulation and plaster, instability of the knee joint from lack of early immobilisation of torn ligaments, non-union of fractures of the scaphoid bone which was preventable, and even non-union and mal-union of the neck of the humerus attributable solely to enthusiasm for the historic and out-of-date teaching of Lucas Championniere Such treatment could still be defended if there was conflict between the demands of anatomical replacement and the demands of functional activity—but there is no such conflict It is easy to maintain the tone of muscles, and to preserve the movement of joints, despite immobilisation in plaster for three or four months No visitor to Royal Air Force Rehabilitation Centres during the recent war would have doubted that the tone and volume of his own spinal musculature was vastly inferior

* WATSON JONES R (1947) Paper presented in summary to the Brussels meeting of the International Orthopaedic Society

to that of pilots whose fractured spines had been immobilised in plaster The test of succ was that the spine was better after treatment than before injury

It would be unjust to imply that the main thesis of Nicoll's contribution is blind advoca of early functional activity On the contrary he has made an important advance first i establishing that the fulcrum of spinal movement is not, as so often has been assumed at th level of the interarticular joints, but at the nucleus pulposus, and then in distinguish clearly the stable fractures that can safely be treated by conservative methods (exercise alo if he is to be believed, and hyperextension in plaster with exercise if we are to be believe from unstable fractures in which we all agree that either spontaneous anterior fusion surgical posterior fusion of the intervertebral joint is needed He has considered in det the sources of such instability—comminution of the vertebral body, rupture of the inte vertebral disc, subluxation of the interarticular joints, and rupture of the interspino ligament It may not be right to compare interspinous ligament ruptures with ruptures o the medial collateral ligament of the knee joint, which share with the corresponding ligam of the elbow joint the unusual feature of curling and rolling of the fibres, or even interpositi within the joint, so that early operative repair is often required But, in general, Nicoll differentiation of stable and unstable fractures is to be accepted

The important question to be determined is whether or not there is truth in the suggesti that in unstable fractures, spontaneous anterior fusion, achieved laboriously after ma months, is better than surgical posterior fusion which can be controlled with precision W must not of course compare spontaneous anterior fusion of a single intervertebral joint wi surgical posterior fusion of many intervertebral joints by the antiquated technique of Alb grafting Some may read with surprise that " undamaged vertebrae are usually included surgical fusion so that four instead of two become fixed " Several years have elapsed sir we learned to use radiographic control in the operating theatre (taking radiographs after t introduction of a metal marker into one spinous process) so that surgical fusion was limit strictly to one intervertebral joint, or sometimes to the two intervertebral joints that w damaged

This contribution on the problems of treatment of dorso-lumbar fractures has the ver great merit that it is stimulating and provocative of further thought It establishes the nee for differentiation of stable from unstable fractures, it leaves us to consider whether stab fractures are best treated by functional activity alone, or by the protection of a hyperexten plaster jacket together with functional activity, and it opens the question as to whether th best result is gained in unstable fractures from spontaneous anterior fusion, or from surgi posterior fusion of the damaged intervertebral joint

As to the management and rehabilitation of patients with traumatic paraplegia, on wh we have invited in this number of the Journal a contribution from Ludwig Guttmann, w work at Stoke Mandeville has achieved such success, we would quote only the words of N from the reports of a group of surgeons who are trying to achieve in Great Britain a gen and unified paraplegia service, comparable in efficiency with the magnificent paraplegic un of Canada and the United States of America which have proved beyond doubt the possibil of restoring the victims of paraplegia to happy and useful lives

" There can be no middle course with this condition Either it must be treated superb well or as badly as possible The worst thing that can happen to these patients, and it happening, is that they should be treated well enough to prevent them from dying but r well enough to make life worth living "

EDITOR

INTERMITTENT CLAUDICATION

A Clinical Study

A M Boyd, A Hall Ratcliffe, R P Jepson and G W H James,
Manchester, England

From the University Department of Surgery Manchester Royal Infirmary

Lameness in horses during exercise was recognised by veterinary surgeons in France and Germany about the middle of the nineteenth century and it was assumed that in some cases this was due to occlusion of the main arteries of the limb In 1831, the syndrome was named " intermittent claudication " by the veterinarian Bouley In 1846, Benjamin Brodie described a similar syndrome in a man " whose femoral artery was converted into a gristly cord, so as to be quite impervious from the origin of the profunda to the point at which it perforates the tendon of the great head of the triceps adductor muscle " He realised that lameness was due to the insufficiency of a reduced arterial supply for the added demands of muscle exercise, and claimed that the condition was to be found principally in " those who drink too much fermented liquor and do not take sufficient exercise " and " especially those who are overfed with animal food "

The description by Charcot (1858) of a patient with an aneurism of the common iliac artery was the first accurate and comprehensive survey of the clinical picture Charcot (1887) and Marinesco (1896) added further clinico-pathological studies Erb (1898) collected many examples, he reviewed the literature and emphasized that, when there was arterial disease, lameness or limping during exercise was due to pain and not to muscle weakness Since that time many excellent studies of the symptomatology and etiology have been published

THEORIES OF THE MECHANISM OF THE PAIN-SYNDROME IN VASCULAR DISEASE

1) **Muscle spasm**—Earlier clinicians were much impressed by the observation in patients with intermittent claudication that occasionally, after exercise, there was palpable change in the consistency of the calf muscles They allowed that the primary cause of pain was arterial deficiency, but thought that the final mechanism initiating the pain was muscle spasm This spasm was likened by Charcot (1858) and Marinesco (1896) to " cadaveric " rigidity, even although the pain of intermittent claudication is continuous and does not fluctuate with each muscle contraction Erb (1898) gave support to this view, but it was abandoned by later writers because in the light of further investigations it proved obviously inadequate

2) **Arterial spasm**—To estimate the rôle played by arteriospasm in intermittent claudication it must first be ascertained whether or not there is actually spasm in the vessels of the limb at the time that pain is felt Evidence has been marshalled by various authors

During exercise the arteriosclerotic foot pales Pallor precedes the pain and it has been assumed that it is due to arterial spasm of the skin vessels, and that the muscle arteries might behave similarly, thus causing pain (Thomas 1922, Zak 1921) We too have observed this pallor during exercise but it is not always present Moreover, pallor may be induced in a severely arteriosclerotic limb by briskly rubbing the skin over the tibia, or by passively flexing the ankle joint a few times The deduction that muscle vessels and skin vessels behave in similar manner is not justified, nor is the assumption that pallor is due to arterial spasm (*vide infra*)

Lian (*cit* Thomas 1929) believed that he had demonstrated spasm in the vessels of the lower limb of a patient with arteriosclerotic claudication by arteriography before and after

exercise Similar studies were repeated in greater detail by Veal and McFetridge (1936) and they showed that exercise-pain was in fact accompanied by dilatation of the vessels, especially those of smaller calibre

After exercise of the arteriosclerotic limb, arterial pulsations at the level of the ankle joint are diminished, or they may disappear, and oscillometric readings taken on the lower leg are correspondingly decreased (Comroe 1923, Leary and Allen 1941) This observation was confirmed in great detail by Ejrup (1948) Both oscillometry and the palpation of vessel measure pulsation of the arterial wall and not flow of blood A more reasonable explanation than that of arterial spasm is that inflow through the major vessels of the limb is limited by the arteriosclerotic process and that these vessels are unable to dilate normally in response to the demands of exercise When structural changes are less advanced, the arterio capillary bed of the muscles increases greatly in capacity and in the course of exercise it abstracts a much larger share of the normal blood supply than when the limb is at rest, and moreover since the systolic stroke of the major vessels is distributed to a greater bed than before pulsation in the medium-sized vessels which is measured by oscillometry is decreased

Claudication has been described in limbs which in the resting state showed no arterial abnormality, yet, on exercise, there was characteristic pain and the pulses disappeared (Pearl 1937) Simmons (1936) stated that "A small proportion of cases of intermittent claudication are due to pure spasm of the arteries in neuropathic individuals and no structural disease of the vessels is demonstrable either at the time or in later years" Such exceptional cases can be explained more satisfactorily by postulating a thrombotic lesion proximal to the femoral artery The collateral circulation is good but not sufficient to supply the great needs of exercise It is noteworthy that the only case of "spastic claudication" described in the literature that has been reviewed at a later date was proved to have organic constriction at the lower part of the aorta (Lindquist 1948, *cit* Ejrup) Two of the authors of this article (Boyd and Jepson 1949) have seen two cases of thrombosis of the external iliac artery with a similar syndrome

3) **Muscle ischaemia as a cause of pain**—In a series of analytical papers, Lewis and his co-workers demonstrated that intermittent claudication was due to inadequacy of blood flow through muscles during exercise causing accumulation in the tissue spaces of a pain factor—"factor P"—which stimulates the sensory nerve endings (Lewis, Pickering and Rothschild 1929, Lewis 1942) Katz (1935) suggested that factor P was a non-volatile acid Lewis showed by occlusion-plethysmography that the arterial bed was dilated at the time of the onset of pain

An extension of Lewis's conception of muscle ischaemia causing pain—In the normal limb it is the muscles that are worked most strenuously in relation to their bulk that first give rise to pain On the other hand, in limbs suffering from arterial disease, instead of all muscles having a blood supply that is approximately equal in relation to their bulk, the arterio-sclerotic process alters the distributive pattern of the arterial supply either by general narrowing of the arteries or by local thrombosis This redistribution differs from limb to limb according to the anatomical structure and the extent and topography of the arteriosclerotic lesions It is the arterial inaccessibility of certain parts of the muscles that causes impaired nutrition and accounts for pain on exercise Pain then arises in that muscle, or part of a muscle, that is worked most strenuously during the complex pattern of walking, and in which the arterial supply relative to the demands of exercise is most deficient This pain on exercise disappears only when the collateral supply becomes adequate, or when the arteriosclerotic process increases and the affected muscle undergoes atrophy, or is replaced by fibrous tissue so that its potential as a focus of deep pain is destroyed

In the arteriosclerotic limb, careful palpation of the musculature reveals patches that are tender to firm pressure This tenderness is, of course, elicited only in superficial muscles and it is noted with particular frequency in the gastrocnemius and sometimes in the small

muscles of the sole of the foot such as the extensor digitorum brevis or in the dorsi-flexors of the foot It may be obvious only after recent exercise, especially if this has been sufficient to give rise to the pain of claudication The area of muscle tenderness varies In limbs that are severely compromised by arterial insufficiency a single muscle or muscle group may be distinctly tender, but in better nourished limbs the patch often measures only a few centimetres in diameter A site that is often tender is the upper part of the medial belly of gastrocnemius

The pain suffered on pressure is likened by the patient to the pain of intermittent claudication The cause of tenderness is not certain but it is probably metabolic in origin and depends upon the same factor that accounts for the pain of exercise When pain is induced by exercising muscles under ischaemic conditions the accompanying muscle tenderness, and the pain itself, disappear rapidly when the blood flow is re-established although as Lewis (1942) pointed out " a little tenderness may remain for an hour or more if the test has been repeated several times " In arteriosclerotic limbs the involved muscles are continually on

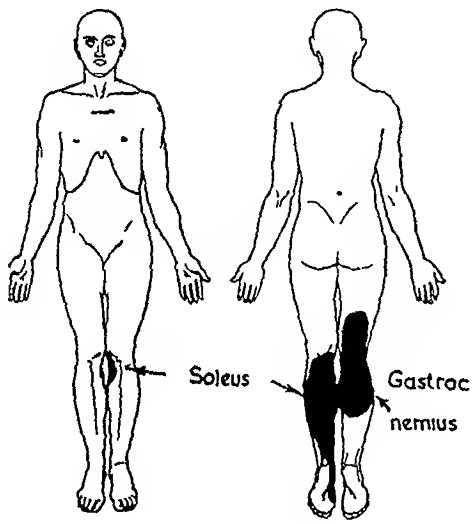

Fig 1

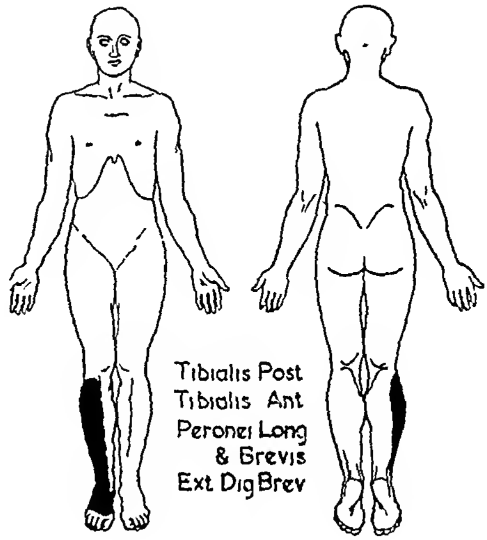

Fig 2

Segmental reference of deep pain from the gastrocnemius and soleus (Fig 1) and from the anterior tibial and peroneal muscles (Fig 2)

the threshold of ischaemic pain and thus the tenderness, which may never entirely disappear, is always emphasized by exercise More intelligent patients may notice a patch of deep tenderness while kneading the calf muscles, but usually no such story is elicited because surface representation of the deep pain may be distant from, and not overlying, its place of origin

Infiltration of the tender area with a few cubic centimetres of 2 per cent novocain makes it anaesthetic to deep pressure and, by blocking the deep pain trigger-point, it allows the patient to walk painlessly for a distance far exceeding that which was possible before injection The increase in walking distance depends upon the degree of arteriosclerotic involvement in other muscles of the limb The new pain that now limits progression is from a different site and, because of its distribution, it is often obvious that it arises from a different muscle Infiltration of the skin or subcutaneous tissues overlying the tender patch does not alter the exercise-tolerance

In order to deduce the muscle of origin from the history of surface-representation of pain, further experimental work was undertaken A reliable method of producing experimental

muscle-pain is that described by Lewis and Kellgren (1939)—namely, the intramuscul injection of 6 per cent hypertonic saline after infiltration of the skin and deep fasci wi local anaesthetic A few cubic centimetres is sufficient to cause deep aching, varying intensity from discomfort to nauseating agony The intensity depends not only on th susceptibility of individuals and the amount of solution injected, but also on the concentrati of pain nerve-endings in the vicinity of the injection These are probably sparse, so that th number of nerve endings that are stimulated varies by chance according to the site of th injected saline It was our impression nevertheless that in patients with claudication, injecti of tender areas, and mechanical stimulation by the needle-point, gave rise more readily pain than similar procedures in "non-tender" areas and in normal muscles Each musc referred to in Figures 1 and 2 was injected in at least six different subjects, usually in bo lower limbs The areas of skin reference for the pain so produced were charted, and compo it areas for many of the more important lower limb muscles were determined The pain com on almost immediately after the injection, it rises rapidly to maximal intensity, and it th falls gradually in four to six minutes The quality is described characteristically as "sickening ache" and is often compared to "cramp" There are ill-defined limits—a smal centre of intense pain tending to shade off to mild aching at the periphery Although limited in spread to the reference areas shown on the charts the pain may be felt far distant from th point of injection, and the site of maximal intensity may move within the area from minut to minute When hypertonic saline is injected into muscles in the neighbourhood of joint (for example into the flexor hallucis longus or the extensor digitorum brevis near the ankl the pain may be referred to the joint itself When a peripheral mixed nerve such as th anterior or posterior tibial is stimulated by adjacent saline, paraesthesia is produced whi is distinguished easily from the dull quality of "deep" muscle pain The whole question o muscle pain is discussed admirably by Kellgren (1938)

CLASSIFICATION OF OBLITERATIVE VASCULAR DISEASE

It seems clear that the immediate cause of intermittent claudication is diminution arterial supply to the muscles concerned, but the reason why the arterial supply is diminishe is less apparent There is much confusion in the terminology used in relation to obliterativ arterial conditions causing circulatory deficiency in the lower limbs Occlusive arterial disea beginning under the age of fifty years is usually classified as "Buerger's disease" o "thromboangiitis obliterans", whereas over the age of fifty years the symptoms of arteri deficiency are usually grouped under the general term, arteriosclerosis Leriche (1947), in a recent analysis of over 500 personal cases, limited the term thromboangiitis obliterans to patients under the age of thirty-five years, in patients over the age of fifty years he attributed the symptoms to arteriosclerosis, but he admitted that there was a third group of patient with ages between thirty-five and fifty years, showing features of both conditions, that h was unable to classify

Review of the arteriographic findings and clinical features in a large number of patient with deficiency of circulation in the lower limbs who were investigated between 1932 an 1949 show that they may be classified under three main headings 1) primary thrombosis o the popliteal artery, 2) juvenile obliterative arteritis, and 3) senile obliterative arteriti— a) diffuse obliterative arteritis, b) secondary popliteal thrombosis, c) secondary femoral thrombosis (Figs 3–14)

Primary thrombosis of the popliteal artery and juvenile obliterative arteritis are usuall included together under the heading "thromboangiitis obliterans" It seems, however, tha in most patients under the age of thirty-five years the cause of claudication is traumati thrombosis and not arterial disease, and this was certainly true in every case in the ser now reported

Juvenile obliterative arteritis comprises a group of cases corresponding to those described by Buerger and this condition may be a pathological entity Buerger himself included under the heading of thromboangitis obliterans patients who, from their symptoms, appeared to be suffering from degenerative arterial changes In this report the term " juvenile obliterative arteritis " is restricted to obliterative arteritis beginning in the feet and following a characteristic clinical course The condition seldom, if ever, begins after the age of thirty-five years

Senile obliterative arteritis is the term used to include the degenerative arterial changes that are commonly associated with increasing age and are included under the general term " arteriosclerosis " Arteriosclerosis is usually considered to be a disease of old age, but careful examination of post-mortem and biopsy material in obliterative arteritis from patients under the age of thirty-five years sometimes reveals arteriosclerosis at an early age Well-marked calcification of the vessels has been seen in the early twenties Arteriosclerosis is undoubtedly the most frequent cause of arterial deficiency in the lower extremities in the fourth decade, and over the age of forty years it accounts for most cases of occlusive vascular disease

In brief, almost all cases of obliterative arteritis in young people up to the age of about thirty-five years fall into one of the first two groups—primary thrombosis of the popliteal artery and juvenile obliterative arteritis, and in patients over the age of thirty-five years into the third group—senile obliterative arteritis The nature of the pathological changes in the blocked vessels is largely speculative, but it is of no great importance from the point of view of treatment which cannot be directed towards cure of the underlying condition or restoration of the function of blocked vessels Attention must be concentrated on the vessels that are still healthy with the object of assisting by every possible means the greatest and most rapid development of a collateral circulation

TABLE I

ANALYSIS OF 472 CASES OF OBLITERATIVE ARTERITIS OF THE LOWER LIMBS

	Men	Women	Total
Traumatic thrombosis	4	1	5
Juvenile obliterative arteritis	8	—	8
Primary popliteal thrombosis	6	—	6
Senile obliterative arteritis	405	48	453
(*a*) Diffuse obliterative arteritis	192	26	218
(*b*) Secondary popliteal thrombosis	165	15	180
(*c*) Secondary femoral thrombosis	48	7	55

PRIMARY THROMBOSIS OF THE POPLITEAL ARTERY

Nearly all patients under the age of thirty-five years who complain of intermittent claudication in the calf muscles have been found to have thrombosis of the popliteal artery Arteriographic studies show that occlusion is confined to this artery, the other vessels appearing healthy The extent of the occluded segment varies it may extend from the level of the knee joint to the adductor opening, from the level of the knee joint to the termination of the artery, or throughout the whole length of the artery from the adductor opening to the bifurcation (Figs 3–6) The fact that one end of the thrombosed segment is often found at the level of the knee joint suggests strongly that the causative process begins at this level Several arteriograms obtained before there was actual thrombosis showed the earliest stage

FIG 3

Primary popliteal thrombosis—pre-thrombotic lesion at the level of the upper border of the femoral condyles (from the Surgical Professorial Unit at St Bartholomew's Hospital by courtesy of Professor Sir James Paterson Ross)

of the lesion, namely, localised narrowing and irregularity of the lumen of the artery in the middle of the popliteal fossa (Fig 3) Arteriograms of patients known to have sustained traumatic thrombosis of the popliteal artery from posterior dislocation of the knee joint (Fig 7) are indistinguishable from primary thrombosis of the artery

Histological examination of the occluded segment obtained by arterectomy from young men suffering from intermittent claudication of the calf muscles, usually thought to be due to "Buerger's disease," shows no evidence of inflammatory changes in the arterial wall (Boyd 1938) The lumen is found to be occluded by healthy clot in various stages of

FIG 4

Primary popliteal thrombosis—thrombosis beginning at the level of the upper border of the femoral condyles has extended proximally as far as the tendon of adductor magnus (by courtesy of Professor Sir James Paterson Ross)

organisation The wall of the artery is normal Patients with this condition have been traced for ten years and there has been no evidence of further arterial disease This is in striking contrast with the after-histories of patients with proved arterial disease ("thromboangiitis obliterans" or arteriosclerosis)

The evidence in favour of primary popliteal thrombosis as a clinical entity may thus be summarised 1) there is similarity of the arteriographic picture with that of traumatic thrombosis from dislocation of the knee joint, 2) there is no inflammatory or degenerative change in the walls of the artery, 3) the clinical course is more suggestive of injury than

FIG 5

Primary popliteal thrombosis—the occlusion has extended distally from the level of the upper border of the femoral condyles proximal extension is probably limited by a large sural artery

constitutional disease In further investigation of this possibility, special studies of anatomy of the popliteal artery were made (Boyd and Wilde 1949)

Anatomy of the popliteal artery—After leaving the adductor hiatus the popliteal art[illegible] lies in loose fatty tissue and is freely mobile Just above the level of the knee joint the art[illegible] enters a fibrous tunnel derived from the fascia on the deep surface of the gastrocnemius T[illegible] fascial covering narrows to form a definite fibrous band, $\frac{1}{4}$ to $\frac{1}{2}$ inch broad, attached to t[illegible] capsule of the knee joint at the level of the joint Arteriograms show that it is at this p[illegible] that thrombosis of the popliteal artery usually occurs It is suggested that injury, fr[illegible]

FIG 6

Primary popliteal thrombosis—thrombosis beginning at the level of the femoral condyles has extended both proximally and distally

normal knee movement or minor sprains and strains, may cause damage to the tunica intima and thrombosis of the vessel The possibility that there may be traumatic thrombosis is obviously increased if there is abnormal fixation of the popliteal artery to the oblique ligament within the fibromuscular canal from inflammatory changes caused by minor infection of the toes or interdigital folds

Care should be taken to distinguish primary thrombosis of the popliteal artery from secondary thrombosis occurring as a complication of senile obliterative arteritis This distinction is fundamental in assessing the prognosis Senile obliterative arteritis often occurs

FIG 7

Traumatic thrombosis of the popliteal artery from posterior dislocation of the knee joint Note that the thrombosis begins at the level of the upper border of the femoral condyles and that the arteriographic appearances are identical with those of primary popliteal thrombosis in which there has been no major bone or joint injury

in the fourth decade On the other hand degenerative arterial changes may be delayed u much later in life Occlusion of the popliteal artery in a man aged thirty-five years may therefore, be due to primary thrombosis, it may be secondary to early senile obliter arteritis, the prognosis then being poor A similar finding in a man aged fifty years, n commonly secondary to degenerative change, could possibly be primary if there was generalised arteriosclerotic change, and in this event the outlook for both life and limb w be good It is clearly important to determine by careful examination of the cardio vasc system whether the thrombosis is primary or secondary

JUVENILE OBLITERATIVE ARTERITIS

For the clinical syndrome in which obliterative arteritis begins distally in the arteries of the feet in young men, the general title " juvenile obliterative arteritis " is preferred to that of thromboangiitis obliterans, or Buerger's Disease The first accurate study of " thromboangiitis obliterans," originally described by Winiwater in 1879, was published by Leo Buerger in 1908 and has since been known by his name " Buerger's disease " like " Raynaud's disease " includes a number of conditions of differing pathology that have been separated from the general group of peripheral vascular disorders in which there is obliterative arteritis of distal distribution The term " Raynaud's phenomena " is now used rather than " Raynaud's disease ", and similarly, for these conditions, some of which are due to arteriosclerosis, " Buerger's syndrome " would be more appropriate than " Buerger's disease "

After separating from this general group cases that are due to degenerative arteritis there remains an obliterative arteritis of obscure origin with characteristic clinical features that might be called " juvenile obliterative arteritis " or " thromboangiitis obliterans "

Juvenile obliterative arteritis seldom, if ever, begins after the age of thirty-five years The obliterative process begins in the small arteries of the feet Gradually, but relentlessly, it ascends the limb until the popliteal or even the femoral vessels are occluded (Figs 8–10) There is often fungus infection of the interdigital folds Patchy phlebitis in the superficial veins may precede the signs of arterial involvement—an occurrence that is seldom seen in arteriosclerosis The pain usually becomes intolerable and by the time the obliterative process involves the popliteal artery amputation is demanded The disease is often more advanced in one limb than the other but it is always bilateral The more recently affected limb may need amputation even before the limb that was first affected

In early cases, arteriography shows narrowing and finally obliteration of the small arteries of the feet In more advanced cases arteriograms show relentless proximal spread of the disease, the tibial arteries, and eventually the popliteal arteries, become involved A line can almost be drawn across the limb at the point to which the disease has reached Collateral vessels show the corkscrew appearance that is associated characteristically with rapid hypertrophy and dilatation—a feature less marked in distal obliterative arteritis of arteriosclerotic origin

Ischaemic pain and colour changes in the toes are often followed rapidly by ulceration and gangrene Intermittent claudication in the small muscles of the sole of the foot, which unfortunately is often mistaken for the symptoms of chronic foot strain, may precede the more obvious phenomena of ischaemia Ulceration occurs early, sometimes with gangrene, and not uncommonly in the presence of palpable pulses at the ankle The course is progressive, though periods of apparent quiescence in one or other leg are often seen One or both limbs are usually lost within three to five years of the onset of the disease

It would appear that juvenile obliterative arteritis is confined to the lower limbs but this is an opinion which may need to be modified in the light of further experience Involvement of the upper limbs is more typical of the distal type of senile obliterative arteritis

Little help is gained from studying pathological changes in the vessels Buerger, in his original study of nineteen amputated legs, described the macroscopic and microscopic changes which he considered to be specific There was macroscopic evidence of perivascular fibrosis welding the artery, vein and nerve into a dense cord of fibrous tissue Microscopy showed inflammatory infiltration of the vessel walls with fibrosis of the adventitia, atrophy of the media, and slight thickening of the intima from proliferation of endothelial cells The lumen of the vessel was blocked by clots in various stages of organisation and, eventually, the thrombus became partly recanalised These changes are seen also in arteriosclerosis Any surgeon who has experience of amputating limbs for senile gangrene will have noticed

FIG 8
Juvenile obliterative arteritis—early stage Thrombosis in the plantar arteries extending as far as the necks of the metatarsals

FIG 9
Juvenile obliterative arteritis—thrombosis has extended proximally to the supramalleolar region

occasional difficulty in separating the components of the neurovascular bundle which a often bound inextricably by fibrous tissue The change is most marked if there has b sepsis with ulceration and gangrene When there has been recent infection the tissue pla around the neurovascular bundle are oedematous In late cases, the inflammatory tiss organised and converted into dense fibrous cords These changes give rise to difficulty wh

FIG 10

Juvenile obliterative arteritis—late stage Extension of thrombosis proximally Thrombosis has nearly reached the bifurcation of the popliteal artery

Peripheral sympathectomy is attempted because isolation of the posterior tibial nerve from the artery and veins may present the greatest difficulty The inflammatory change depends largely upon the degree of infection in the perivascular lymphatics Specimens of the posterior tibial artery obtained by arterectomy in early cases, before there was infection and ulceration, do not show such marked perivascular fibrosis

SENILE OBLITERATIVE ARTERITIS

This group includes the great majority of patients who complain of symptoms due to arterial deficiency The degenerative arterial changes are most marked in the lower limb It is important to lay stress on the fact that senile obliterative arteritis is not confined to old age, it is seen in patients with wide variation of age Marked atheroma has been recorded in young children, and it is by no means rare in the third decade, it is the most frequent cause of occlusive arterial disease between the ages of thirty and forty years, and it accounts for practically all cases of organic obliterative arterial change after the age of forty years

a) **Diffuse obliterative arteritis**—Arteriography shows narrowing and irregularity of the main vessels with a beaded appearance of the larger branches (Fig 11) Sometimes the pathological changes seem to fall principally on the main vessels, the smaller branches are abundant, and a collateral circulation is well developed This is the most common group and there is often calcification of the arterial walls In others, changes in the main vessels are less marked, the most noticeable features are the paucity of muscle branches which appear to end abruptly, the absence of collateral anastomoses, and the pronounced muscle wasting

There is a third group, small but interesting, in which the most marked clinical feature is coldness of the feet and often of the hands The toes, and sometimes the feet, are deeply cyanotic and cold but they become pink and warm when vasoconstriction is abolished by reflex heating or by paravertebral block of the lumbar sympathetic chain There is little or any muscle wasting Oscillometric readings are normal as far down as the ankle In all three groups the blood pressure is usually high

b) **Secondary popliteal thrombosis**—Thrombosis of the popliteal artery occurs in nearly half the patients with diffuse arterial disease The arteriographic picture (Fig 12) resembles that of primary popliteal thrombosis Thrombosis begins in the segment of the popliteal artery behind the knee joint where the artery is attached to the capsule of the joint by a fibrous band In diffuse obliterative arteritis arteriography shows the greatest changes in this segment Repeated minor injuries caused by flexion and extension of the knee joint probably determine localisation of the disease to this part of the vessel Thrombosis, beginning in the condylar region, usually extends upwards as far as the adductor opening (Fig 13) Sometimes however, distal extension occurs with occlusion of the lower half of the artery and the first few inches of the tibial vessels Occasionally thrombosis extends in both directions, thus involving the entire length of the popliteal artery The extent of thrombosis is probably determined by the calibre of branches leaving the artery, proximal spread being limited by the brisk flow through the anastomotica magna and distal spread by the flow through a large sural artery The onset of thrombosis may be determined by injury or by lowering of the blood pressure with diminution of blood flow due to confinement to bed by reason of illness or operation The effect of secondary popliteal thrombosis depends upon the degree to which the collateral circulation has already developed If the calibre of the main vessels has been diminished gradually over a long period of time the collateral circulation is well developed and the effect of a new lesion on the peripheral circulation is negligible, but if thrombosis occurs early in the disease, severe ischaemia is bound to result

c) **Secondary femoral thrombosis**—Thrombosis of the superficial femoral artery is much less frequent In the series now reported it occurred in only fifty-five of 472 patients Arteriography shows occlusion of the superficial femoral artery from the adductor opening to the point where the profunda femoris leaves the main trunk (Fig 16) Thrombosis has been shown to begin in the region of the adductor opening, proximal extension being limited by the brisk flow of blood through the profunda femoris (Fig 14) Arteriograms in diffuse obliterative arteritis often show gross deformity of the femoral vessel at the level of the adductor opening where the artery may be tethered to the margin of the tendinous opening

FIG 11
Senile obliterative arteritis—*a*) Diffuse obliterative arteritis

The occurrence of femoral thrombosis is determined by much the same factors as those of popliteal thrombosis The effect on the circulation in the limb depends, as in popliteal thrombosis, on the extent to which the collateral circulation has developed Generally speaking the higher the block the less marked are the effects on the peripheral circulation

Femoral thrombosis is to be suspected clinically if there is claudication in the calf of a limb which appears to be unusually healthy Nutritional changes in the skin, nails and muscles—so commonly seen in secondary popliteal thrombosis—are seldom found when the femoral artery is occluded Nevertheless in femoral thrombosis, distal extension with gangrene of the limb occurs more commonly than in popliteal thrombosis

FIG 12

Senile obliterative arteritis—b) Secondary politeal thrombosis Early lesion beginning at the level of the upper border of the femoral condyles

CLINICAL INVESTIGATION

Most patients in this series were first seen in the Neurovascular Out-patient Clinic of t Manchester Royal Infirmary Investigation in the out-patient department was desig primarily to enable the surgeon to decide whether treatment could be given as an out-pati or whether it was advisable to admit the patient for further study Peripheral vascu disease is of course part of a generalised degenerative change, the patient must be as as a whole, and it is not possible to carry out complete examination of the cardio-vas system in a busy out-patient clinic, but before operative procedures were undertaken de

FIG 13

Senile obliterative arteritis—b) Secondary popliteal thrombosis (note extension of thrombosis upwards as far as the opening of adductor magnus)

in-patient investigation was always made Salient features in the history and clinical findings were recorded on a printed proforma which recorded the location of pain, the approximate date when it was first noticed, the suddenness of onset, the distance walked at the time of onset and at the time of examination, and the presence or absence of coldness, numbness or rest pain A record was made of history of injury, frostbite or phlebitis, of the amount of tobacco smoked, and of the age and cause of death of the parents Clinical data included records of the general health, the state of the heart and blood pressure, the nutrition of the limb as estimated on an arbitrary scale—Grades I, II and III—the presence or absence of

FIG 14

Senile obliterative arteritis—c) Secondary femoral thrombosis—early lesion at the level of the adductor opening

muscle wasting, atrophy of the small muscles, atrophy of the nails, and colour change Records of walking-ability included the rate of walking, the site of pain after walking, the time of onset, the time of halting, the radiation of pain, and the relation of walking t diminution or stabilisation of pain The pulses and oscillometric readings in both lower limb were recorded on a chart Oscillometric readings were taken above and below the knee, and above the ankle The oscillometer is not an instrument of precision but it does allo assessment of changes in the pulsation of main vessels Reduced oscillations throughout th limb are characteristic of diffuse obliterative arteritis, complete absence of oscillation

FIG 15

Senile obliterative arteritis—illustrating the progress of a secondary femoral thrombosis

usually found below a main vessel block, though it is to be noted that if the collateral circulation is well developed there may be slight excursion of the needle One of the authors (A M B) has used the oscillometer for fifteen years and during that time arteriography of doubtful cases has never revealed evidence of main vessel block that was not suspected by oscillometry

Investigations thus outlined determine the underlying cause of claudication, and the clinical history of the localisation of pain indicates which muscles are involved It remains to confirm the observations of the patient by examining his reactions to measured degrees

FIG 16

Senile obliterative arteritis—c) Secondary femoral thrombosis—fully developed secondary thrombosis of the superficial femoral artery

of exercise, and also to assess the severity of the condition The circulatory deficiency must be estimated in terms of the demands made by the individual upon his blood supply The primary concern of a patient is the interference with his daily life caused by pain in the leg and, when the limb is not in danger, treatment must be directed to the relief of subjective manifestations Estimates of the relative deficiency were therefore made by testing the ability of each patient to walk at his own rate under controlled conditions This was done first by walking over a known circuit of the hospital corridors, but the test has now been replaced by walking on a machine specially constructed for the purpose (Fig 17) An endl

belt, driven by an electric motor at a speed ranging from one to four and a half miles per hour, is fitted with a tachometer giving the speed in miles per hour and the distance travelled by a point on the belt The patient steps forward from a stationary platform on to the belt which is moving towards him at the slowest speed, and the speed of the belt is then increased gradually until he believes that he is walking at a normal rate

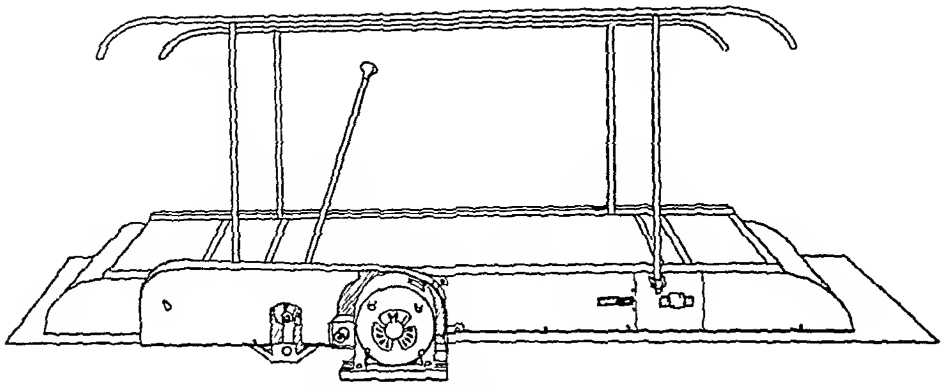

FIG 17

The claudicometer—exercise tolerance machine

Such a machine permits direct observation of the limb throughout the test It has been noted that sometimes there is pallor of the feet at the onset of claudication Oscillometry after the exercise-period sometimes shows reduced readings, contrary to the usual finding of a marked increase During the exercise-test the patient describes his sensations From the data thus obtained it is possible to classify the type of arterial disorder

CLASSIFICATION INTO CLINICAL TYPES

The hypothesis that there are three clinical types of claudication depends upon consideration of the events taking place in a muscle during exercise The resting muscle has a scanty blood supply, but when it is exercised there is capillary vasodilatation (Krogh 1922) If the muscle is exercised under ischaemic conditions there will be pain (Lewis, Pickering and Rothschild 1929) It cannot be doubted that the protatic event in these phenomena is the accumulation of metabolites—both in the case of vasodilatation and of pain (Hamilton 1947, Lewis 1942) It is beyond the scope of this paper to discuss the mechanism involved, the nature of the various metabolites concerned, or their mode of action The basic concept is not affected

With the onset of muscle-exercise, metabolites accumulate until the threshold for the reaction of vasodilatation is reached, such increase in blood supply dissipating the metabolites by chemical or physical processes Eventually equilibrium is reached—the metabolites being eliminated at the same rate that they are produced The level at which this takes place depends, for a given rate of exercise, upon the available blood supply In the normal individual equilibrium is reached before the metabolites accumulate sufficiently to produce pain In the patient with claudication the threshold of pain-reaction is reached before equilibrium is attained Figure 18 is an attempt to express this diagrammatically, the horizontal axis represents time from the beginning of exercise, the vertical axis represents accumulation of metabolites, curve (a) is that of a normal individual, curve (b) is that of a patient with claudication The dotted lines show the levels of metabolites required to initiate the increase of blood supply ("vasodilatation") and the pain reaction

Most patients with intermittent claudication find that when pain begins it is relieved quickly by a short period of rest and thereafter they can go on walking In such cases,

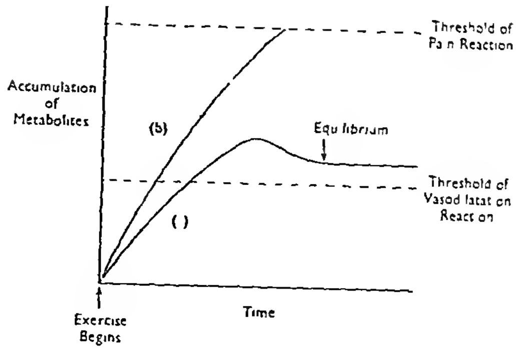

FIG 18

Curves representing reaction to exercise in the normal individual (curve (a) and the patient with claudication (curve (b)

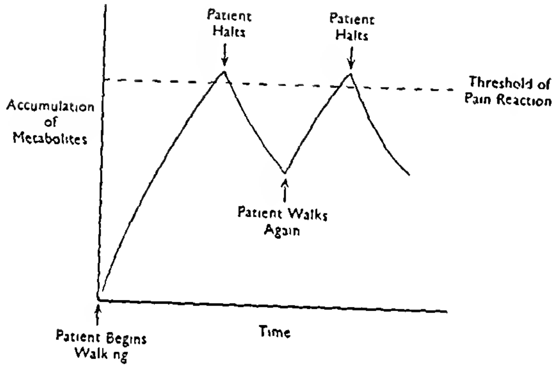

FIG 19

Alternating exercise and rest in intermittent claudication

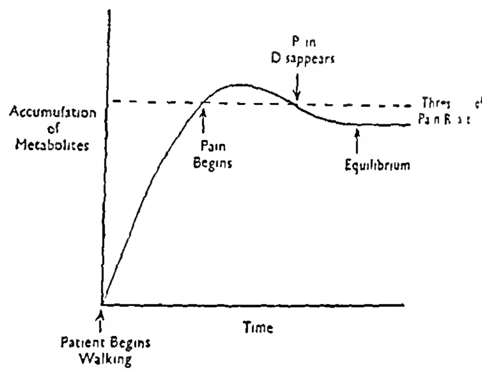

FIG 20

Reaction to continued exercise in Type 1 claudication

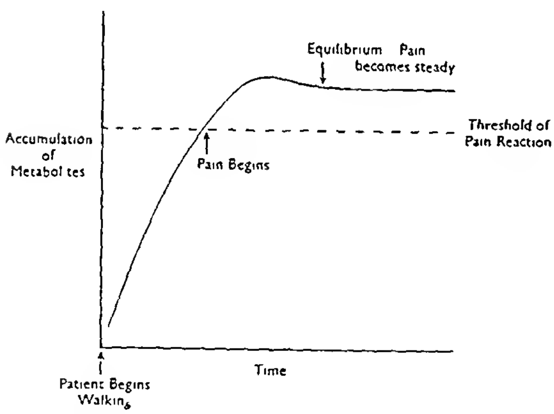

FIG 21

Reaction to continued exercise in Type 2 claudication

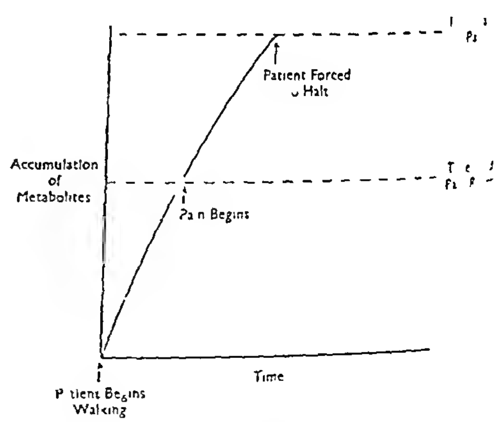

FIG 22

Reaction to continued exercise in Type 3 claudication

metabolites were accumulated until the threshold was reached and they were dissipated during the rest period, only to rise again when walking was resumed (Fig 19)

When a patient is asked to walk for the purposes of investigation he is not allowed to rest when pain first develops, he is urged to continue walking as long as possible The events that occur after the onset of claudication vary according to the relationship of blood supply to the demand and three types of reaction may be distinguished *Type* 1—In this type th

blood supply and demand are very nearly equal. When the patient is urged to continue walking he announces, usually in a surprised tone, that the pain has disappeared. Here the level of metabolites crosses the pain threshold before a position of equilibrium is reached, but when equilibrium is finally attained it is below the threshold (Fig. 20). The fact that equilibrium has been attained just below the threshold of pain can be demonstrated by making the patient walk more quickly than usual; pain then returns. *Type* 2—Most patients belong to this group. When the patient continues walking the pain attains a steady level and eventually he stops walking not because of the intensity of the pain but because of its persistence. Equilibrium is attained only above the threshold for pain-reaction (Fig. 21). *Type* 3—Here the blood supply is so far reduced that stability cannot be achieved; on being urged to walk further the patient complains that the intensity of pain is increasing; finally it becomes intolerable so that he is forced to halt. In this case the position of equilibrium is at so high a level that it cannot be reached because in attempting to achieve it there is unbearable pain (Fig. 22).

TREATMENT OF INTERMITTENT CLAUDICATION

General considerations—If traumatic thrombosis is excluded, the arterial condition that underlies intermittent claudication is widespread, progressive and ultimately fatal. Lack of knowledge of the etiology of the responsible arterial conditions limits the treatment of intermittent claudication to alleviation of the subjective manifestations that interfere with the daily life of the patient. The most rational method of relieving exercise-pain would be to increase the blood supply in order that the demand of exercising muscles might be met. When the deficit is small this can be done, but in severe cases the gap between supply and demand may be too great, or it may not be possible to increase the blood supply because there is severe occlusive change in a group of muscular vessels. Under these conditions relief can be gained only by reducing the function of the affected muscles.

In practice the problem is more complex than one of simple supply and demand. Each individual case must be considered carefully and many factors of varying importance must be assessed accurately, always making allowance for the fact that many patients are poor witnesses and that it is not always easy to determine the degree to which an individual is inconvenienced by claudication, or indeed whether he is claudicating at all.

Factors influencing the choice of treatment—1) *Clinical type*—In determining treatment, the clinical type of claudication is by far the most important factor and this cannot be over-emphasized. Failure to appreciate that there are different grades of claudication has led, on the one hand, to extravagant claims for the success of certain drugs or methods of treatment and, on the other, to disrepute of sound and logical procedures. The general principles of treatment that are indicated in each clinical group can be defined clearly. *Clinical Type* 1—In this type, supply and demand are almost equal. The very slightest increase in blood flow brings about complete relief of exercise-pain and there is a good response to any method of treatment that improves the blood supply. Suggestion is a powerful factor in any form of treatment and it may have particular application to patients who suffer from claudication. If the patient is a Type I claudicant he will respond to almost any method of treatment, provided only that his confidence is gained, and this accounts for the reputation that has been gained for Buerger's exercises, intermittent venous occlusion, and the administration of muscular extracts, hormones and anti-coagulants. *Clinical Type* 2—In this type of claudication the gap between supply and demand is much wider and relief can be gained only by bridging the gap. As a rule the supply is increased to meet the demand, but in certain cases the demand may be reduced to meet the supply. Sometimes a combination of both methods may be adopted. *Clinical Type* 3—In this type the gap between supply and demand can be narrowed but never closed—a fact that is of fundamental importance. Disappointment is

bound to result from operative treatment or from any measure that is designed solely t improve the blood flow Relief from severe pain can be secured only by reducing the funct of the muscles by neurectomy or tenotomy

2) *Age*—The age of the patient has an important bearing on treatment, the younger he i the more necessary is it to secure the greatest possible increase in blood supply Generally speaking, lumbar sympathectomy should be advocated in patients under the age of forty t fifty years regardless of the clinical category in which they may fall, not only because i younger patients it may be possible to improve the general nutrition of the limb, and l attention to general health to delay the progress of arteriosclerotic change, but also because th longer the patient has to live the more likely it is that amputation will be needed sooner or late

3) *Type of arterial disease*—Estimation of the severity and type of the causative arteri condition is of great importance in planning treatment In traumatic thrombosis the ex pectation of life is normal and the only danger is that of local failure of the collateral chann to undergo sufficient hypertrophy and hyperplasia The most vigorous and dependab method of increasing blood supply and encouraging the collateral circulation is indicate The questions that arise are what is the risk to life, and what is the risk of losing the limb *The risk to life*—Experience during the last eighteen years has shown that in diffu obliterative arteritis, with calcification of the main vessels, loss of life is more likely th loss of the limb These patients often suffer from hypertension, coronary thrombosis ... heart failure and cerebral complications, sometimes there are mesenteric vascular accide Calcified vessels associated with hypertension show little tendency to thrombosis, peripheral gangrene is unusual In general, angina of effort, past history of coron thrombosis, dyspnoea on exertion, and hypertension are contra-indications to lumb sympathectomy Lumbar sympathectomy should be advised only in patients with diffu obliterative arteritis and calcification of the main vessels when it is felt that the limb it is in danger *The risk of losing the limb*—Peripheral gangrene leading to loss of the limb more likely to occur in obliterative arteritis complicated by secondary thrombosis of a m vessel, especially when the superficial femoral artery is involved Patients with second thrombosis of the superficial femoral artery nearly always have a normal or low blo pressure and are specially prone to massive thrombosis followed by extensive gangrene I Type 3 claudicants, where no more than a pain-relieving procedure is indicated, an effort t improve the blood flow should always be made This applies also to patients with superfici femoral thrombosis

4) *Other painful conditions in the limb*—It is not surprising that claudication in patients wh are past middle-age, brought about by degenerative arterial changes, is often associated w other signs of wear and tear of the tissues The clinical picture is often complicated b osteoarthritis, chronic foot strain, deep thrombo-phlebitis or varicosity of the veins Th contribution of each of these conditions to the disability must be estimated It is clearly o no value to gain operative relief from claudication if, in fact, the pain was due to osteoarthriti of the knee joint Much help can be gained in differentiating joint, muscle and vascul pains by infiltration of the popliteal or tibial nerves with novocain, and by paravertebr block of the lumbar ganglia By repeating walking tests after the various nerve blocks it usually possible to determine the relative importance of each source of pain

5) *Influence of associated disease*—Chronic bronchitis and emphysema, angina of effort, or obesity, are often associated with arteriosclerosis and intermittent claudication r operations for the relief of intermittent claudication should not be undertaken if, in fact the halting of the patient is due to dyspnoea The importance of these conditions can be be determined by direct observation under walking conditions Diabetes, unless mild well controlled, worsens the prognosis and accounts for rapid progress in the arterio-sl ... changes and the development of peripheral gangrene Diabetes must be excluded b decisions are made as to treatment

6) *Economic and geographical factors*—The necessity for immediate and complete relief of pain may arise from the inability of a patient to walk long distances to and from his work, and sometimes the contours of the country in which he lives may be a determining factor. A wealthy patient, with car and chauffeur, who is brought to a halt at 150 yards may have no need, and indeed no inclination, to walk more than 100 yards and he can be treated palliatively, whereas a patient able to walk 400 yards who is compelled to walk half a mile to his work requires direct attack on the affected muscle.

Details of treatment—Buerger's exercises, contrast baths, intermittent venous occlusion, suction-pressure and similar measures of treatment had been prescribed in many cases included in this series before we first saw them but without any real evidence of improvement. We believe that they are of little value and have not used them. The methods of treatment that have been employed will be discussed under the headings 1) methods of improving the blood supply, 2) methods of decreasing the vascular demands of muscles, 3) methods of relieving pain. The results, with brief comments, are tabulated at the end of each paragraph.

The classification of results calls for a word of explanation. Success claimed for 100 per cent. improvement might in practice mean no more than an increase in walking distance from one to two hundred yards. It was decided therefore to classify results under three headings: *Good*, meaning complete relief from pain or ability to walk one mile without pain, *Improved*, indicating that the patient was able to walk a useful distance, arbitrarily fixed at half a mile, without pain, *Unrelieved*, including patients in whom the walking distance was often much increased but was still not accepted as being of economic value.

METHODS OF IMPROVING THE BLOOD SUPPLY

Lumbar ganglionectomy—The quickest, the most radical, and in general the most satisfactory way of improving the blood supply is by sympathectomy. Evidence of calcification of the main vessels is no contra-indication to sympathetic denervation. Some of the most successful results of sympathectomy in senile obliterative arteritis have been gained in patients with radiographic evidence of calcification of the main vessels. Release of normal tone increases the blood flow even if there is no evidence of abnormal vasoconstriction. Generally speaking, lumbar ganglionectomy should be undertaken in all patients below the age of sixty years if the general condition does not contra-indicate operation. The first, second and third lumbar ganglia, with the intervening chain, should be removed in order to be certain that denervation is complete. The more usual operation, in which only the second and third ganglia are removed, is apt to result in incomplete denervation (Jepson and Ratcliffe 1949).

In patients over the age of sixty years lumbar ganglionectomy is not always advisable but if the general cardio-vascular condition is satisfactory there seems no reason why sympathectomy should not be undertaken even in these older patients. If it is believed that the risk of operation is not justified, chemical destruction of the sympathetic chain with 10 per cent. phenol is worth considering (Haxton 1947).

TABLE II
RESULTS OF GANGLIONECTOMY IN SIXTY-THREE CASES

	Good	Improved	Unrelieved
Type 1	1	—	—
Type 2	36	11	5
Type 3	—	4	6

Comments on treatment by lumbar ganglionectomy—The results of lumbar ganglionectomy for arteriosclerosis confirm our previous views that this simple operation offers the best chance of rapid and certain improvement. The patient is allowed to get up on the fourth day and is discharged from hospital on the eighth or ninth day after operation. In many cases, walking

tests carried out on the day that they are discharged from hospital show great improve- In others there is little immediate change but review one month later shows improve- The distance that they can walk without pain steadily increases until most of them can a mile or more in comfort The operative mortality is low In this series, there w death from coronary thrombosis on the ninth post-operative day Altogether 632 lu ganglionectomies have been performed between January 1947 and March 1949 with death Two patients had cerebral thrombosis within forty-eight hours of operation but recovered completely within a few weeks

Paravertebral block with 10 per cent phenol—Chemical destruction of the lumb ganglia has proved to be of great value in patients in whom lumbar ganglionectomy is contra-indicated by reason of advanced age or impairment of general condition The u [illegible] hol has been abandoned almost entirely on account of the not infrequent occurre [illegible] ular palsy and severe neuralgia due to unavoidable inclusion of the spinal nerv [illegible] t injection Mandl (1948) showed in cats that 6 per cent phenol had a selective [illegible] n the sympathetic ganglia causing complete destruction without damaging the spinal n H A Haxton (1947), working in the Neurovascular Unit at the Manchester Royal Infirm ggested 6 per cent phenol for paravertebral block of the lumbar chain Haxton's [illegible] ses in which he used 5 cubic centimetres of 6 per cent phenol, showed evidence of incom sympathetic denervation without undesirable sequelae In order to accomplish more com destruction of the lumbar ganglia he increased the strength of the phenol solution to 10 and the quantity injected to 10 or 15 cubic centimetres Paravertebral block with [illegible] ubic centimetres of 10 per cent aqueous solution of phenol has been used in th [illegible] rge number of patients since May 1947, with gratifying results So far no complicat [illegible] sort have been met

[illegible] paravertebral block—The equipment needed is a 10 c c Labat syringe a fine [illegible] ermal injection 12 cm and 16 cm rustless steel needles 0 8–1 mm diameter 2 per cent novo [illegible] 10 per cent aqueous solution of phenol The injection can be carried out easily in bed The pati lies on his side with a pillow under the loin in order to separate the lumbar transverse proce [illegible] It is important that the back should be kept straight, avoiding either flexion or extension and th trunk should be in a strict lateral position at right-angles to the bed The foot of the bed i ra 10-inch blocks in order to encourage seepage of the phenol upwards along the tissue planes an sympathetic chain thus reaching the first lumbar or even the twelfth dorsal ganglia

The bedclothes should be removed so that the lower extremities are exposed to room tem about 20 C being ideal The skin temperature of the feet preferably on the inner side of th recorded readings being taken every few minutes until the skin temperature reaches a steady level skin preparation and isolation of the lumbar region with sterile towels an intradermal wheal i with 2 per cent novocain at a point near the outer border of the erector spinae four fingers bread to the spine of the second lumbar vertebra A 16 centimetre needle is most commonly used 1 centimetre needle is adequate in small and thin individuals The needle is passed obliquely th selected point, directed medially at an angle of about 30 degrees from the horizontal plane The operat make a mental picture of the relations of the erector spinae, psoas muscle and vertebral bodie an imaginary line from the point of injection to the front of the body of the second lumbar ve [illegible]

By this technique the needle often passes lateral to the tip of the transverse proce If the transverse process should be felt the needle be withdrawn a little inclined slightly up downwards in order to pass above or below the bone, and then advanced a further 4 or 5 centime the psoas muscle until the antero-lateral aspect of the vertebral body is reached Occasionally i passes in front of the vertebral body and pierces the aorta or vena cava Puncture of the great harmless and is in fact a useful indication of the position of the needle point If this occur should be withdrawn and reinserted at a greater angle until bone is felt When the needle i placed satisfactorily in close proximity to the lumbar chain after careful aspiration in ord certain that the spinal theca or a blood vessel has not been entered 2 cubic centimetres c 2 per cent novocain solution is injected

If the needle has been placed correctly a rise of skin temperature, usually first detectab over the medial side of the heel below the medial malleolus will be recorded within two or th A large rise in the skin temperature cannot be expected in patients with advanced arteri

any patient, however in whom phenol block is indicated, there will be some elevation of skin temperature A rise of even one degree, occurring within two or three minutes shows that the needle is correctly placed

If there is no alteration in skin temperature within five minutes, the needle should be withdrawn and reinserted at a different angle and the novocain injection repeated *It is unwise to inject the phenol* solution unless the point of the needle is proved to be correctly placed Only when the operator is satisfied with the position of the needle should 10 to 15 cubic centimetres of 10 per cent aqueous solution of phenol be injected The phenol may not be in complete solution at room temperature If the fluid is cloudy the bottle should be warmed by standing it in hot water for a few minutes until the phenol is completely dissolved The syringe also should be warm

The patient should remain in the lateral position for twenty minutes in order to keep the pool of phenol in contact with the lumbar ganglia He may then be turned on his back and the blocks removed from the foot of the bed He should remain flat on his back for one hour, after which he can return home with instructions to lie down for the rest of the day

TABLE III
RESULTS OF PHENOL INJECTION IN TWENTY-SEVEN CASES

	Good	Improved	Unrelieved
Type 1	3	—	—
Type 2	5	9	4
Type 3	—	—	6

Comments on treatment by paravertebral block with phenol—Chemical sympathectomy with 10 per cent phenol has a definite though limited place The method has been used in patients over the age of sixty years and in those in whom lumbar ganglionectomy was contra-indicated by reason of their general condition Paravertebral block with phenol has been used also in advanced Type 3 cases where the patient complained of a cold foot or where the feet showed severe nutritional changes or incipient gangrene

Vitamin E (α-tocopherol) therapy—It is unfortunate that the use of α-tocopherol in cardio-vascular conditions has been exploited by the popular press as a new "miracle drug" critics have applied the principle "*Falsus in uno, falsus in omne*" and thereby discredited favourable observations The treatment was supported by Vogelsang and Shute (1947, 1948) and criticised by Baer and Heine (1948, 1949) The authors did not feel convinced by the arguments presented on either side and decided that observations should be made on selected cases Vitamin E was given to Type 2 cases who were awaiting admission to hospital Ten patients were given daily doses of 200 milligrammes of α-tocopherol (Ephynal, Roche) Their progress was reviewed after one month They stated that they felt better but assessment of walking-ability showed little if any change In every case, however, there was noticeable objective improvement after two months The dose of "Ephynal" was increased to 300 milligrammes daily with further improvement Larger doses have been used since, but it would appear that a daily dosage of 400 milligrammes is optimal In view of these results it was considered that further observations were warranted Vitamin E has also been given with benefit to patients with severe nutritional changes in the feet

TABLE IV
RESULTS OF TREATMENT WITH α-TOCOPHEROL IN EIGHTY-ONE CASES

	Good	Improved	Unrelieved
Type 1	5	—	—
Type 2	27	32	13
Type 3	—	—	4

Analysis of the cases treated with α-tocopherol is shown in Table IV It must be emphasized that these figures are derived only from clinical observation The number of variables is such that strictly controlled experiments must of necessity involve long term studies these are being undertaken and the results will be reported in due course

Comments on treatment by α-tocopherol therapy—α-tocopherol is the only substance th has given consistently good results in cases other than those grouped in Type 1 Patients with vascular disorders of Type 2 and 3 who had previously been treated with other dru without benefit showed definite improvement when treated with "Ephynal T consistency with which there was a lag period of four to six weeks before improvement w noted was most striking After a few months there was much improvement in the appearan of the feet in patients who showed nutritional changes

METHODS OF DECREASING THE VASCULAR DEMAND BY MUSCLES

Thiouracil—A trial of thiouracil in the treatment of intermittent claudication was initiat by a chance observation A patient attended the Vascular Clinic of the Manchester Roy Infirmary who had suffered for many months with Type 3 claudication and was also sever thyrotoxic (B M R +50 per cent) It was decided that the thyrotoxicosis should be controll with thiouracil before treatment of the claudication was undertaken When a normal B M had been reached, and the clinical manifestations of hyperthyroidism were controlled, it w discovered that the pain of claudication was greatly relieved

TABLE V
RESULTS OF TREATMENT BY THIOURACIL IN THIRTY-ONE CASES

	Good	Improved	Unrelieved
Type 1	1	—	—
Type 2	6	1	16
Type 3	—	—	7

Thirty-one patients with intermittent claudication of mixed types, whose B M R 's an blood cholesterols were within normal limits, were then treated by a prolonged course thiouracil until a state of early myxoedema, confirmed by B M R and blood cholester readings, was reached

Comments on treatment by thiouracil—No significant improvement was noted in this group a whole, even in cases that developed severe myxoedema Our conclusion is that thiourac is not warranted as a form of treatment for intermittent claudication

METHODS OF RELIEVING PAIN

Antistin—The work of Barsoum and Gaddum (1935) suggested that in the ischaemic lim the histamine content of venous blood was increased This statement has not been accepte generally but it seemed wise to try the effects of anti-histamine drugs to see if relief could b afforded to patients with claudication Antistin was selected for trial because it appeared t

TABLE VI
RESULTS OF ANTISTIN THERAPY IN TWENTY-SIX CASES

	Good	Improved	Unrelieved
Type 1	5	—	1
Type 2	—	4	13
Type 3	—	—	3

have the least undesirable side-effects, and it was given to twenty-six patients in a dail dosage ranging from 300 milligrammes to 900 milligrammes according to tolerance The were many unpleasant side-effects including headache, nausea and vomiting One patien lost his sense of smell but recovered it when administration of the drug was stopped Th were two cases of cerebral thrombosis but these may have been coincidental In view of t variable tolerance and the high incidence of side-effects, the treatment was discontinue

Comments on antistin therapy—The mixed properties of the anti-histamine compounds at present available make it very difficult to assess their mode of action in intermittent claudication The unpleasant side-effects make their use undesirable

Myoneurectomy—*Internal popliteal neurectomy*—The possibility of relieving the pain of intermittent claudication by division of branches of the internal popliteal nerve to the gastrocnemius occurred to Sir James Learmonth and ourselves independently and at about the same time While one of us (A M Boyd) was in charge of a Centre for Vascular Injuries in Egypt during the recent war it was observed that whereas ligation of the popliteal vessels usually gave rise to intermittent claudication, some patients were still able to walk without pain after excision of an aneurism in the popliteal fossa It was noted that patients who did not complain of the pain of claudication had paralysis of the gastrocnemii, doubtless through division or stretching of branches of the internal popliteal nerve during exposure of the aneurism The significance of this observation was not appreciated until 1947 when an arteriovenous aneurism of the popliteal artery was operated upon and the gastrocnemius was paralysed Thereafter it was decided to divide the nerves to both heads of the gastrocnemius in patients with severe claudication

In practice, the operation proved disappointing, although much interesting information was obtained Patients who were relieved of the pain of claudication in the gastrocnemius nevertheless suffered pain in the soleus after walking a further hundred yards or so The necessity of knowing the skin reference of pain from various muscles of the limb was thus revealed and for this reason studies of the cutaneous reference of pain from these muscles were undertaken (*vide supra*)

Division of the external popliteal nerve—Three patients complained of severe exercise pain in the extensors of the leg which halted them after walking 100 yards or less The external popliteal nerve was infiltrated with 2 per cent novocain and walking tests were then repeated All three were relieved of pain and were able to walk more than half a mile in comfort They did not mind the foot-drop and all agreed that the external popliteal nerve should be divided The nerve was exposed through a half-inch incision over the neck of the fibula, it was crushed and divided All three patients were able to walk painlessly on the second day after operation So far they have remained satisfied

Division of the posterior tibial nerve—A lady aged sixty years, weighing 18 stone (252 pounds) complained of severe pain in the left calf and in the sole of the left foot under the heads of all the metatarsals, it was difficult to determine which pain was the more crippling There was diffuse obliterative arteritis and early nutritional changes in the foot Paravertebral block with 10 per cent phenol relieved the exercise-pain in the left calf, but the patient was halted at seventy yards by pain under the heads of the metatarsals The posterior tibial nerve at the level of the ankle joint was infiltrated with 2 per cent novocain, after which she was able to walk a quarter of a mile in comfort, being halted only by dyspnoea Division of the nerve just above the ankle joint gave complete relief

Tenotomy of the tendo Achillis—Sir Heneage Ogilvie (1949), in his Beyer Memorial Lecture, drew attention to the value of occasional idleness In this erudite address, Ogilvie stressed the necessity of having time to think One of us (A M B) enjoyed such a period of idleness in an inn in Somerset, listening to local gossip, and in that time the possible value of tenotomy of the tendo Achillis occurred to him He learned that in the latter part of the nineteenth century a general practitioner in that vicinity did all his rounds on horse-back and kept his horses until they were too lame to work, whereupon he divided a tendon near the hoof and thereby gained from them another five years of work Horses are prone to claudication and it seemed that relief was obtained by dividing the tendon of the affected muscles

After consultation with our orthopaedic colleagues we decided that division of the tendo Achillis might relieve exercise-pain in the calf muscles The first patient upon whom this operation was performed was one with Type 3 claudication with exercise-pain in the right

calf which halted him at seventy yards After division of the tendo Achillis he was able to walk two miles without pain on the third day after operation He is now walking five miles daily in a hilly district in Wales carrying on his job as a postman The operation of subcutaneous tenotomy of the tendo Achillis can be carried out in a few seconds under pentothal anaesthesia The tendon is divided with a fine sharp tenotome just above the heel The tenotomy knife is inserted on the medial side and the tendon is divided from within outward There is no bleeding The patient is able to get up the next day and most of them are able to walk half to one mile, others complain of pain at the site of operation and defer walking until the second or third day By the fourth day after operation all patients are able to walk more than one mile without pain There have been no complications and no serious disabilities after operation The gait is almost normal and not noticeably worse than before operation Plantar-flexion is of course weakened but most patients are able to rise on their toes After a few months the severed ends of the tendon become united with lengthening but the patients are still free from exercise-pain

TABLE VII

RESULTS OF TENOTOMY OF THE TENDO ACHILLIS IN TWENTY-FOUR PATIENTS

	Good	Improved	Unrelieved
Type 1	—	—	—
Type 2	6	—	—
Type 3	16	2	—

Comments on treatment by tenotomy of the tendo Achillis—This simple but eminently satisfactory operation has replaced popliteal myoneurectomy in this clinic The operation was originally restricted to Type 3 cases It was felt, however, that the results were so satisfactory that late Type 2 patients, whose improvement by other methods had been inadequate, might be included

GENERAL COMMENTS

The most successful treatment for the Type 3 case of intermittent claudication, in which the blood supply is so far reduced that stability cannot be achieved by any attempt to improve the vascular supply, is undoubtedly tenotomy of the tendo Achillis All except two patients have been able to walk more than a mile thereafter and the two who halted at less than that distance did so because of anginal pain The operation, although trivial in itself, does cause slight disability and certainly will not permit elderly and shuffling patients with claudication to walk with the brisk gait of young men whose pain has been relieved It does, however, relieve them of the pain which has made their lives a misery and it enables them to spend their remaining days in reasonable activity For the Type 2 case of claudication, when age and general condition permit, lumbar ganglionectomy must be rated as the most successful treatment In more elderly patients chemical sympathectomy has its place Further comment on the results of treatment with α-tocopherol must be withheld until the results of controlled experiments are known Type 1 cases can be cured by any form of therapy in which the patient has faith The one failure in this series was a patient who could not be persuaded that his condition was not incurable

SUMMARY

1 A description is given of historical discoveries relating to intermittent claudication Various theories that have been advanced are discussed A hypothesis, based on the work of Lewis, is elaborated

2 A classification of obliterative arterial disease is outlined The three groups that are distinguished are primary thrombosis of the popliteal artery, juvenile obliterative arteritis and senile obliterative arteritis

3 The methods adopted for assessment of the severity of disease, including study of the clinical features, arteriographic findings, results of novocain infiltration and examination of the patient on a walking machine, are reported

4 Methods of treatment by Buerger's exercises, contrast baths, intermittent venous occlusion and suction pressure, by lumbar ganglionectomy and paravertebral block with phenol, by vitamin E (α-tocopherol) therapy, by treatment with thiouracil and antistin, by internal popliteal myoneurectomy and division of the external popliteal and posterior tibial nerves, and by tenotomy of the tendo Achillis, are discussed

5 It is concluded that tenotomy of the tendo Achillis should replace myoneurectomy in Type 3 cases where the blood supply is so far reduced that vascular stability cannot be achieved, and that it might apply in Type 2 cases in which there is persistent pain at a steady level

6 The results of treatment in 276 patients with intermittent claudication are recorded

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THE FATE OF VOLUNTARY MUSCLE AFTER VASCULAR INJURY IN MAN

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Much has been written about the fate of voluntary muscle that has been partly or who[lly] deprived of its blood supply, but there is still disagreement as to the pathogenesis of t[he] lesions Confusion is understandable because ischaemic damage of muscle is encountered i[n] many types of case and on the basis of clinical and experimental findings it has b[een] attributed to many different causes It is found in open wounds with injury to the m[ain] vessels or their muscular branches, in closed injuries of the limbs with damage to the ves[sels] and in acute embolic catastrophies Ischaemia of more gradual onset may be due t[o] thrombosis of arteries or veins, or to the accumulation of fluid or the swelling of mu[scle] within a rigidly bound space such as the anterior tibial compartment

Ischaemic damage of muscle has been ascribed to arterial occlusion (Volkmann 18[..], Griffiths 1940, Barnes and Trueta 1942, Parkes 1945, Cohen 1948), arterial spasm (Len[...] 1935, Cohen 1941, 1944, 1948), venous obstruction (Brooks 1922, Brooks and Martin 19[..] Brooks, Johnson and Kirtley 1934, Middleton 1930), external pressure alone (Jepson 1[...] Lewis 1936), external pressure with ligation of veins (Jepson 1926), capillary paral[ysis] (Leveuf 1937), and peripheral nerve injuries (Putti 1938)

Clearly, as pointed out by Leveuf (1937), Griffiths (1940), and Parkes (1945), conditi[ons] of different etiology and pathology have been grouped together solely on the ground that th[ey] produce contracture in voluntary muscles In fact, however, two lesions of strikingly differe[nt] type have been reported one is characterised by massive necrosis of contractile tissue a[nd] in the other there is dense intramuscular fibrosis Classification of these lesions cannot b[e] based satisfactorily on clinical findings alone, but histological classification may serve t[o] distinguish them and shed light on the problems of etiology

Biopsies of muscle were taken from sixteen patients with vascular lesions treated at t[he] Peripheral Nerve Injury Centre in Oxford The methods of clinical examination that [...]

Figures 1–9

All preparations are of human muscle Unless otherwise stated the material has been stained w[ith] [...] modification of Bielschowsky s technique FIG 1—Muscle fibres from a case of early necrosis T[he] nuclei are still visible but there is variation in the intensity of the staining reaction in different m[uscle] fibres FIG 2—Discoidal fragmentation of muscle fibres in a necrotic area (haematoxylin and eo[sin]) FIG 3—Cross-section of muscle showing a sharply defined area of necrotic muscle fibres surrounded b[y a] zone of phagocytic and fibroblastic activity Note the dense acellular fibrosis at the periphery (M[ason] stain) FIGS 4–5—Phagocytic activity leading to breakdown of the fibres at the edge of the ne[crotic] mass of muscle (Hortega silver carbonate stain) FIG 6—Scattered fragments of necrotic muscle fib[res] within the connective tissue in an area of incomplete devascularisation adjacent to an area of m[...] necrosis (Mason stain) FIG 7—Incomplete devascularisation of muscle Note the ill defined border [...] of vascular connective tissue which is infiltrating between the muscle fibres Note the wavy outline [of] these muscle fibres in some of which there is an apparent increase in the sub sarcolemmal nuclei Th[ese] findings indicate the effect of denervation (Hortega silver carbonate stain) FIG 8—Showing t[wo] adjacent areas of vascular damage which is complete on the right and incomplete on the left Co[mpare] the sharp and ill-defined borders of the two regions (Hortega silver carbonate stain) FIG 9—Re[generation] of muscle fibres in an area of incomplete devascularisation Note the multinucleated and bulbous [...] the myotubes on the left

Fig 1

Fig 2

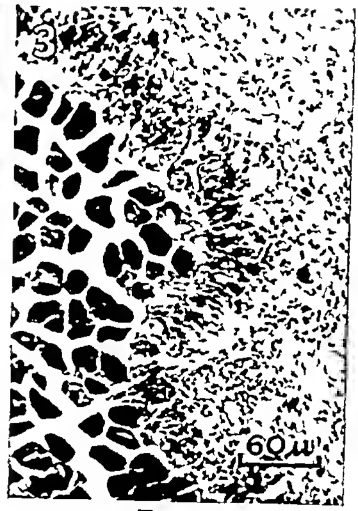

Fig 3

Fig 4

Fig 5

Fig 6

Fig 7

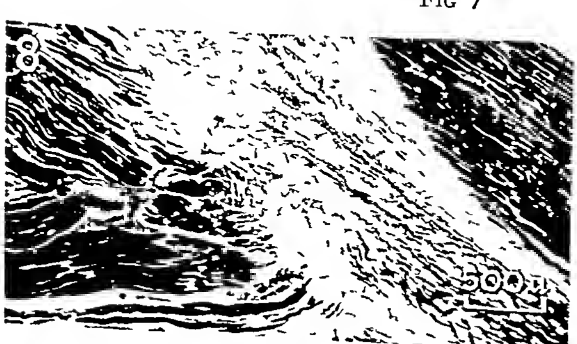

Fig 8

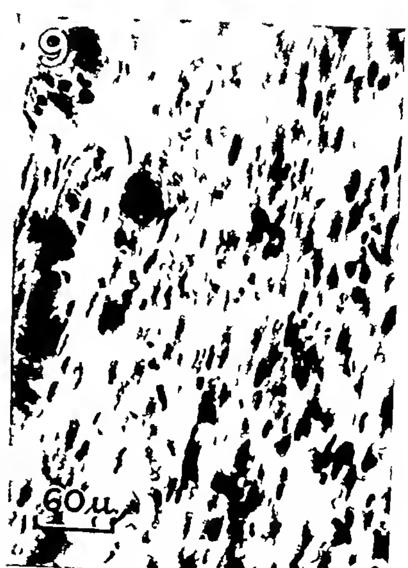

Fig 9

FIG 10

FIG 11

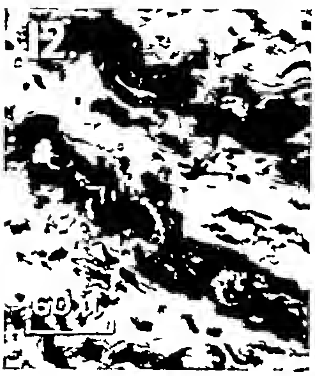

FIG 12

FIG 13

FIG 14

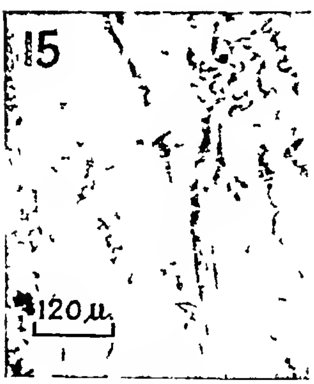

FIG 15

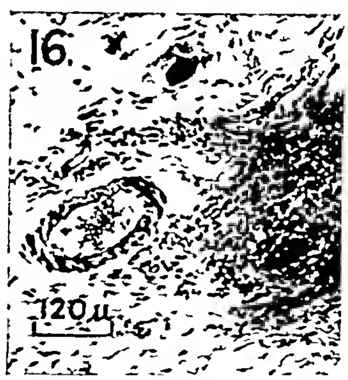

FIG 16

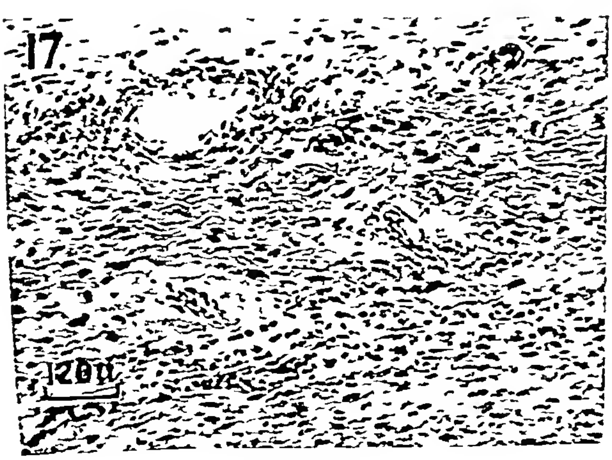

FIG 17

FIG 18

used have been reported previously by Holmes, Highet and Seddon (1944), and the method of taking the biopsies, and the histological technique employed, were described by Bowden and Gutmann (1945)

Three types of lesion in muscle—The clinical and histological findings are summarised in Table I Many observers have described the changes that occur in muscle after vascular damage but a summary of the findings in this series is relevant Three main types of lesion could be distinguished histologically In the first there was massive necrosis of muscle fibres, the necrotic areas being surrounded by a sharply defined zone of fibrous tissue, in the second there was dense interstitial fibrosis, and the third group showed elements of both these types in that there were scattered foci of necrosis together with interstitial fibrosis

Group 1—*Massive necrosis of muscle*—Biopsy was performed in five patients, at intervals ranging from 40 to 800 days after injury The muscles were hard and friable with patches of yellow-green necrotic tissue When muscle fibres could be identified they were arranged in straight lines, some were of normal diameter and some were swollen There was no evidence of fibrillar structure within the muscle fibres which showed considerable variation in staining-reaction even in a single section (Fig 1) In longstanding cases no nuclei were seen, but in more recent ones there were a few small nuclei of abnormal appearance and staining-reaction When cross-striation was present it was unusually clear, although again there was no uniformity of staining (Figs 1 and 2) Transverse discoidal fragmentation was easily recognised (Figs 2 and 4) The necrotic areas were surrounded by a clearly defined zone of fibrous tissue but there was complete absence of fibrosis between the necrotic muscle fibres (Fig 3) In more recent cases the collagen fibres were loosely arranged, enmeshing a few red blood cells In later ones the fibres were densely packed, especially at the periphery At the inner margin of this ring of fibrosis there was evidence of activity by macrophages which appeared to be breaking the muscle fibres into fragments, some no larger than a single horizontal band (Figs 4 and 5) As these remnants of muscle were removed they were apparently replaced by fibrous tissue Similar changes have been reported by Kraske (1879), Leser (1894), Scott (quoted by Burrows 1918), Bristow (quoting Greenfield 1923), Griffiths (1940), Barnes and Trueta (1942), Le Gros Clark and Blomfield (1945), and others

In areas adjacent to the site of necrosis there were ill-defined zones of highly vascular connective tissue (Figs 6–8) The muscle fibres scattered throughout this fibrous tissue showed signs of necrosis (Fig 6), denervation (Fig 7) or regeneration (Fig 9) The richly nucleated and bulbous muscle fibres that were seen in this zone afforded proof of the possibility of recovery of function by the regeneration of contractile tissue

The endothelium of intramuscular blood vessels showed proliferation but it was impossible to judge whether this endothelial hyperplasia was the cause or the result of the necrosis of muscle (Fig 10) The intramuscular pattern of innervation was also studied In five cases in which massive necrosis was found, empty nerve trunks were seen in areas adjacent to the necrosis (Figs 11 and 12) In specimens from two patients thin axons, resembling regenerated nerve fibres, were seen penetrating the empty Schwann tubes (Fig 13) In one, the axons and

Figures 10–18

All preparations are of human muscle Unless otherwise stated the material has been stained with a modification of Bielschowsky's technique Fig 10—Showing an artery with narrowed lumen and endothelial proliferation in an area adjacent to a patch of necrosis (haematoxylin and eosin) Fig 11—Note the empty nerve trunk on the left of a patch of completely necrotic muscle fibres which show marked lack of uniformity in staining reaction Fig 12—Empty Schwann tubes lying in connective tissue adjacent to an area of necrosis Fig 13—Nerve trunk adjacent to a necrotic area Note the thin regenerating axons (Ax) Fig 14—Dense intramuscular fibrosis Note the muscle fibres scattered in the connective tissue Fig 15—Degenerated muscle fibres showing as homogeneous bands within connective tissue in which there are scattered nuclei Fig 16—Infiltration of perivascular region by small round cells (haematoxylin and eosin) Fig 17—Perivascular infiltrations in an area of dense fibrosis Fig 18—Fibrosis and small round cell infiltration between muscle fibres which show the effect of denervation

TABLE I

Case	Age in years	Nature of Injury Associated lesions and abnormalities	Time in days between injury and biopsy	Clinical Evidence of Circulatory Disturbance: Approximate time of onset	At time of biopsy: Pulse	At time of biopsy: Oscillometry	Arteriogram	Functional Tests of Muscles: Muscles: Consistency	Contracture	Voluntary power (footnote 1)	Electrical reactions (footnote 2): Faradism	Galvanism
Group I												
1 B 178	8	Supracondylar fracture humerus Median ulnar and incomplete radial palsy ? Tight plaster	40	1 hour	Absent	—	—	Flexors hard Intrinsics soft	+++ 0	0 0	— 0	— S
2 35	37	Colles' fracture Ischaemic nerve lesions Tight plaster	120	12 hours	Good	Diminished lower half forearm	Obstruction radial artery at level of fracture	Hard in hand and lower half forearm	+++	4 Hand 0	0 0	0 S
3 G 58	27	Fracture radius and ulna Ischaemic lesions median and ulnar nerves Tight plaster	180	24 hours	Good	No abnormality detected	Narrowing of brachial artery Absent muscular branches Break in anterior interosseous artery	Firm flexors Intrinsics soft	++ 0	0 0	0 0	0 S
4 B 72	20	Dislocation of elbow Median ulnar and radial nerve lesions Splinted with acute flexion of elbow Severe burn later	221	24 hours	Weak	—	Constriction of brachial artery	Firm below elbow	+++	Forearm 1 Hand 0	0 0	0 S High
5 G 24	60	Multiple fractures Complete brachial plexus lesion Severe bruising upper limb	800	20 hours	Absent	Absent	Complete obstruction of the brachial artery at the level of neck of humerus	Firm	++	Prox 2-3 Dist 0	— 0	[illegible] 0
Group II												
6 J 43	29	None known Plasma vitamin C 0 03 mg 100 cc (Normal 0 3)	95	2-3 days	Slightly diminished	Slightly diminished	No lesion seen	Firm	Extensor hallucis longus only	2 Extensor digitorum longus 0	0 0	— 0
7 A 30	20	Pain after kicking ball Incomplete lateral popliteal nerve injury Haematoma	106	6–12 hours	Good	Slightly increased	Technically unsatisfactory	Firm	+	3	0	0
8 P 57	26	Shell wound Incomplete division of ulnar nerve Sepsis	150	No note	Gravitational cyanosis	—	—	Soft	0	Ulnar innervation 0 Median ?	0	S

FOOTNOTES TO TABLE I

1 Voluntary Power—
- 0 = paralysed
- 1 = flicker
- 2 = movement of joint with gravity eliminated
- 3 = movement against gravity
- 4 = movement against resistance but weaker than normal
- 5 = normal

2 Electrical Reactions—Percutaneous faradic and galvanic stimulation—
- 0 = no reaction
- — = response
- S = sluggish contraction
- High = abnormally high threshold stimulus

3 Histology—Nerve fibres—
- 0 = None seen
- 1 = Few thin nerve fibres seen many empty tubes No innervated end plates
- 2 = Nearly all nerve trunks innervated ... nerve fibres a few thicker myelinated ... innervated end plates
- 3 = All nerve trunks innervated axons ... and myelination not yet normal
- 4 = Normal pattern and degree of inn...

TABLE I

Sensory and Sudomotor Changes	Operative Findings			Histology (footnote 3)			Clinical Progress (footnotes 4 and 5)
	Muscles	Vessels	Nerves	Muscle	Nerve fibres	Prognosis	
c anaesthesia nd analgesia idrosis except in terdigital clefts	Lower half of flexors necrotic	Brachial artery 2 mm in diameter over a length of 8 cms, feeble pulse	Ulnar slightly indurated and swollen Median acute angulation over fracture, slightly indurated	Necrosis predominant Some regeneration of muscle fibres	1	C	Radial M_4 S_2 Median M_4 S_2 Ulnar M_3 S_2 Three months after injury (No further information available)
ve anaesthesia nalgesia and anhidrosis	Severe patchy necrosis	Radial pulse absent at level of fracture	Median and ulnar fibrotic and shrunken due to ischaemia (footnote 6)	Necrosis predominant Foci of fibrosis with denervated fibres	—	C	Radial M_3 Median $M_1(_5)$ S_1 Ulnar M_2 S_3 Six years after injury
ove anaesthesia and analgesia ating diminished ticularly in the periphery	Hard friable, necrotic	Muscle branches and anterior interosseous artery fibrous cords only	Shrunken and fibrotic for 7 cms Ischaemic lesion	Necrosis with regeneration of muscle fibres	1	B	M_5 S_4 Two years after injury
ove anaesthesia analgesia and anhidrosis	Friable necrotic, thick capsule	Brachial artery constricted for 4 cms	Fibrotic	Necrotic	0	C	Radial M_4 S_1 Median M_2 S_1 Ulnar M_2 S_0 Five years after injury
oaesthesia poalgesia ove anhidrosis	Necrotic	—	Median and ulnar fibrotic, shrunken Ischaemic (footnote 7)	Necrosis and fibrosis of muscle	—	C	Median M_1 S_1+ Ulnar M_1 S_1+ Five years after injury
esthesia first toe interdigital cleft lgesia less exten Slight hyper osis under test	Pale	—	—	Dense fibrosis No necrosis of muscle fibres	—	C	M_3 S_4 Two years after injury
omplete lateral liteal anaesthesia analgesia or weating change	Pale not hard	Fragile	Normal	Early collagenisation Many extravasations No necrosis of muscle fibres	—	C	M_3 S_4 Four years after injury
ir anaesthesia and lgesia incom e anhidrosis in ribution of the ulnar nerve	Slightly pale	No abnormality detected	Ulnar nerve gross scarring Resection and suture necessary	F C U fibrosis Ruptured veins Extravasation of blood Moderately severe denervation atrophy	1–2	B	M_1 S_2+ Four years after injury

FOOTNOTES TO TABLE I

4 Recovery of motor power—

M_0 — Absence of contraction
M_1 = Return of perceptible contraction in the proximal muscle Figures in parenthesis after this indicate strength of muscles
M_2 = Return of perceptible contraction in the proximal and distal muscles
M_3 — Recovery of function in important distal muscles sufficiently strong to overcome resistance
M_4 — Recovery of function as in 3 but in addition there is recovery of independent and synergic movement
M_5 — Complete recovery

5 Recovery of sensation—

S_0=Absence of sensibility in the autonomous zone
S_1=Recovery of deep pain sensibility in the autonomous zone
S_2=Partial recovery of superficial touch and pain
S_3=Complete recovery of touch and pain without any abnormal response
S_4=Recovery as in 3 but with additional recovery of two point discrimination

6 Case 5 of Holmes Highet and Seddon (1944)

7 Case 4 of Holmes Highet and Seddon (1944)

TABLE I

Case	Age in years	Nature of Injury. Associated lesions and abnormalities	Time in days between injury and biopsy	Clinical Evidence of Circulatory Disturbance: Approximate time of onset	At time of biopsy: Pulse	At time of biopsy: Oscillometry	Arteriogram	Functional Tests of Muscles — Muscles: Consistency	Contracture	Voluntary power (footnote 1)	Electrical reaction (footnote 2): Faradism	Galvanism
9 W 119	33	Multiple shell wounds. Compound fracture humerus. Division of brachial artery, vein and median nerve. Incomplete division of ulnar nerve. Gross sepsis	178	+	Absent	—	—	Firm	+++ —	0 0	0 Oedema 0	0 S
10 M 59A	30	Multiple shell wounds. Division of femoral vein	210	No note	Absent	—	Slight narrowing of femoral artery	Firm	+	0 0	0 0	0 0
11 B 94	28	Compound fracture of radius and ulna. Median and ? radial nerve injury. Tight plaster	700	No note	Radial absent. Ulnar present	—	—	Slightly firm	+	In muscles examined histologically 0	High	S
Group III												
12 S 110	40	Stubbed toe when playing football. Plasma vitamin C 0·02 mgm. %	126	4 days	Good	Increased	Lumen narrowed as vessel passed into anterior tibial compartment	Hard	0	0 2	0 0	0 0
13 121	23	Accidental intramuscular transfusion	150	No note	Good	Both legs damaged	—	Hard	+	0	0	0
14 L 24	10	Supracondylar fracture humerus. Median, ulnar and incomplete radial nerve injuries	180	½ hour	Weak	Diminished	Constriction of brachial artery	Firm proximally, soft distally	+ 0	1–2 0	+ 0	- S
15 H 64	21	Fracture R. tibia and fibula lower third. Gross swelling. ? Tight plaster second to ninth day. Skeletal traction applied tenth day. Sciatic palsy noted three weeks after injury	210–240	+	Good	Diminished	—	Soft	—	FLH, ELH, EDB 2–3. Intrinsics 0	0 Oedema	
16 M 65	30	Multiple shell wounds. Compound fracture humerus and elbow. Severe incomplete lesions of radial, median and ulnar nerves. Division radial and ulnar arteries. Sepsis	331	+	Absent	—	—	Hard	+++	0	0	0

FOOTNOTES TO TABLE I

1. Voluntary Power—
   - 0 = paralysed
   - 1 = flicker
   - 2 = movement of joint with gravity eliminated
   - 3 = movement against gravity
   - 4 = movement against resistance but weaker than normal
   - 5 = normal

2. Electrical Reactions—Percutaneous faradic and galvanic stimulation—
   - 0 = no reaction
   - + = response
   - S = sluggish contraction
   - High = abnormally high threshold stimulus

3. Histology—Nerve fibres—
   - 0 = None seen
   - 1 = Few thin nerve fibres seen, many empty tubes. No innervated end plates
   - 2 = Nearly all nerve trunks innervated [illegible] nerve fibres, a few thicker [illegible] innervated end plates
   - 3 = All nerve trunks innervated, axons [illegible] and myelination not yet normal
   - 4 = Normal pattern and degree of [illegible]

TABLE I

ensnry and Sudomntor Changes	Operative Findings: Muscles	Operative Findings: Vessels	Operative Findings: Nerves	Histology (footnote 3): Muscle	Histology: Nerve fibres	Histology: Prognosis	Clinical Progress (footnotes 4 and 5)
an and ulnar sthesia and gesia Glove anhidrosis	Pale	—	—	Dense fibrosis Intramuscular extravasations of blood	0	C–B	Median M_1+ S_0 Ulnar M_1 S_1+ Four years after injury
plete sciatic sthesia and ge ia Complete al popliteal and mplete medial iteal anhidrosis	Pale	No abnormality detected	No abnormality detected	Dense fibrosis scattered extravasations of blood Mixed degeneration and denervation of muscle fibres	—	B	M_3 S_3 Three years after injury
ian and super l radial sensory loss Glove anhidrosis	Pale	Venous engorgement	10 cms threadlike grey avascular trunk Peripheral stump vascular but shrunken	Dense fibrosis No necrosis of muscle but atrophy of denervation Scattered extravasations of blood	—	C–B	No change Repair of nerve impossible
None	Tibialis anterior necrotic Extensor digitorum longus yellow	—	—	Dense fibrosis Extravasation and perivascular infiltration Arteries thick Foci of necrotic muscle fibres	—	C	$M_4+(3+)$ S_4 Three years after injury
ral popliteal an esia analgesia d anhidrosis	Yellow green necrotic	—	—	Dense fibrosis Extravasations, perivascular infiltrations Scattered foci of necrotic muscle fibres	0–1	D	Lat pop M_1 S_1+ Four years after injury
e hyperaesthe ia d hyperalgesia tchy anhidrosis	Prox muscle pale Distal half of flexors patchy necrosis	Brachial artery 2 mm external diameter	Median and ulnar normal	PRT minor degree vascular lesion Patchy dense fibrosis small areas necrosis Atrophy of denervation	4 0–2	B	M_4 S_4 Patient died five years after injury
tic anaesthesia analgesia and anhidrosis	Pale	—	—	Early collagenisation, patchy necrosis with atrophy of denervation	1–2	B	M_5 S_4 Two years after injury
hy areas of thesia analgesia anhidrosis in e distribution	Pale and wasted	—	—	Dense fibrosis many small collagenised extravasations of blood Scattered necrotic muscle fibres	0–1	C	Radial M_0 S— Median M_1 S_2 Ulnar M_0 S_0 Five years after injury

FOOTNOTES TO TABLE I

4 Recovery of motor power—

- M_0 = Absence of contraction
- M_1 — Return of perceptible contraction in the proximal muscle Figures in parenthesis after this indicate strength of muscles
- M_2 Return of perceptible contraction in the proximal and distal muscles
- M_3 = Recovery of function in important distal muscles sufficiently strong to overcome resistance
- M_4 Recovery of function as in 3 but in addition there is recovery of independent and synergic movement
- M_5 Complete recovery

5 Recovery of sensation—

- S_0 = Absence of sensibility in the autonomous zone
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- S_4 = Recovery as in 3 but with additional recovery of two point discrimination

6 Case 5 of Holmes Highet and Seddon (1944)

7 Case 4 of Holmes Highet and Seddon (1944)

When there is accumulation of blood or exudate beneath deep fascia, particularly r rigidly bound space such as the anterior tibio-fibular compartment, the presence or ab of necrosis in the muscles must depend upon the degree of pressure achieved If this be sufficient to occlude the arteries and arterioles, or to initiate arterial spasm, necrosis m ensue, whereas if the venous return alone is impeded there might be interstitial oedema w subsequent fibrosis It is implicit in this hypothesis that tension within the tissues of a clo compartment may exceed arterial pressure Such pressure can be developed only by incre in the effective osmotic pressure of the extravascular tissue fluids, but unfortunately th are no records of measurement of the subfascial pressure in reported cases It is not diffic to envisage circulatory embarrassment when there are large accumulations of fluid un pressure, but it is less easy to see how slow and uncomplicated intramuscular haemorrh can lead to necrosis of muscle as in Cases 6 and 7 The etiology of these lesions is n fully understood

The series of cases reported here supports the concept put forward by Parkes (191 " On the whole the evidence seems to be in favour of Griffith's contention that true Volkmann ischaemia with massive necrosis of muscle fibres and their subsequent replacement by fibro tissue is due to the deprivation of arterial blood supply generally as the result of traum arterial spasm Nevertheless, there is little doubt that a form of muscle contracture clinica resembling the true Volkmann type, though probably without the typical histological pictu can occur from venous or capillary occlusion "

Significance of the intramuscular vascular pattern—While the duration and extent vascular disturbance are of primary importance, other points demand consideration T well-known susceptibility of certain muscles such as the flexors of the forearm, and t relative immunity of the forearm extensors and intrinsic muscles of the hand, may be du several factors As Parkes (1945) points out, these ischaemic lesions might be caused b arterial spasm of the branches to the flexor muscles, or to quantitatively differing metab demands in the two groups of muscle The work of Campbell and Pennefather (1919), Po (1945), Blomfield and Le Gros Clark (1945), and Blomfield (1945) suggests that there is another factor, namely the intramuscular vascular pattern in the individual muscles

Le Gros Clark and Blomfield investigated the efficiency of intramuscular anastomo in the leg muscles of the rabbit They showed that in any particular muscle the vascul pattern was relatively constant By tying off part of the vascular supply to a muscle, or of it, they could induce necrosis The extent of the area affected depended on the site of th vascular damage and the efficiency of the anastomosis Provided that the anastomo is wa adequate, the necrotic area, which was first replaced by fibrous tissue, was later inva from the periphery by regenerating muscle fibres It is clear that extensive fibrosis mi hinder the growth of these regenerating fibres

Blomfield, examining human material, found that there were five main typ intramuscular vascular pattern In the first, there was a longitudinal anastomotic c entering the muscle throughout most of its length, soleus and peroneus longus showed th arrangement of vessels The second type was one in which a longitudinal pattern of ve was derived from a single group of arteries arising from a common stem and entering t muscle at one end, as in gastrocnemius—a muscle which is notoriously susceptibl ischaemia and therefore to clostridial infection In the third group, to which biceps brac belongs, there were radiating vessels arising from a single nutrient artery which entered t middle part of the muscle In the fourth group there was a series of anastomotic lo throughout the length of the muscle, the vessels were derived from a succession of arter entering the muscle at different levels Tibialis anterior, extensor hallucis longus and t long flexors of the toes showed this type of vascular supply Lastly, there was a group which sparse anastomoses were arranged in an open quadrilateral pattern Blomfield concl that the vulnerability of a muscle to vascular injury was determined by the relation o

site of injury to the nutrient vessels, the number of the nutrient vessels, the efficiency of the intramuscular anastomoses, the vascular pattern, and the relation between the volume of the muscle and the size of the main nutrient vessels

Prognosis—The prognosis after vascular injury depends upon the relative size of the masses of viable and non-viable tissue, the possibility of regeneration of muscle, and the state of the nerve supply of the muscle The muscle injury may be associated with mechanical or ischaemic damage to the main nerve trunk or to the intramuscular nerves The additional problem of re-innervation therefore arises, though if the greater part of the muscle has been damaged irreparably, even the most complete degree of re-innervation would be useless Dense interstitial fibrosis is probably irreversible, and recovery after massive necrosis of muscle can be the result only of regeneration of the remaining viable muscle fibres, or of recovery of previously denervated fibres

SUMMARY

1 Biopsies of muscle were taken during the course of operation from sixteen patients with vascular injuries to the limbs Three types of histological change were found

2 In the first, there was massive necrosis of muscle fibres—a group of cases in which there had always been serious damage to the main artery of the limb or to the vessel supplying the affected muscles

3 In the second type there was dense interstitial fibrosis, the muscle fibres sometimes being normal and sometimes showing necrosis or denervation—a group of cases in which the vascular injury varied from severance of the vessels by gunshot wounds to trivial damage, causing slow haemorrhage within fascial-bound spaces

4 The third type showed scattered foci of necrosis together with patchy interstitial fibrosis —due to the pressure of tight plasters, crushing of the limb, fractures with arterial contusion, or slow haemorrhage or extravascular transfusion within fascial planes The rise of tension within the muscles was probably sufficient to occlude the smaller arterioles with resultant patchy necrosis

5 The vulnerability of certain muscles to vascular damage is partly related to the intramuscular vascular pattern, of which five types have been described

6 In ischaemic muscles the intramuscular nerve trunks may be normal or they may show evidence of degeneration or necrosis, but in favourable circumstances there may be regeneration of axons

7 In some cases there was evidence of regeneration of muscle fibres in man, the regeneration being dependent to some extent upon the efficiency of intramuscular anastomoses

8 The prognosis, in cases of ischaemia of human voluntary muscle, depends upon the extent and the reversibility of damage to both muscle and nerve fibres and upon the extent of regeneration of muscle fibres

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SOLITARY PLASMOCYTOMA OF THE SPINE

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The rarity of solitary plasmocytoma of bone justifies publication of this case of a solitary plasmocytoma of the spine The opportunity is taken to review authentic cases of the disease in the literature

CASE REPORT

A male aged fifty-six years tent erector was admitted to the Royal Cancer Hospital on October 15, 1947 with paraplegia

Clinical history—On September 1, 1947, he was lifting a heavy weight and felt something give in his back One and a half hours later he suffered abdominal pain On September 10, 1947, he was admitted to another hospital on account of girdle pains He noticed that his toes were numb and later they became paralysed The paralysis extended upwards as far as the level of the umbilicus

FIG 1

FIG 2

Solitary plasmocytoma of the spine Radiographs of the mid-dorsal region showing forward subluxation of the sixth dorsal vertebra and extensive destruction of two vertebral bodies

Clinical examination—The general condition was good No gross abnormality was detected in the heart and lungs Apart from the paralysis the abdomen was normal Girdle pain and hyperaesthesia were present along the distribution of the sixth dorsal segment Below this level there was paraplegia and anaesthesia There was incontinence of urine

Investigations—*Radiographic examination of bones* (Figs 1 and 2)—*Spine*—Forward subluxation of the sixth dorsal vertebra with incomplete destruction of two bodies—appearances suggestive of a secondary deposit from a tumour The rest of the spine showed no abnormality Radiographs of the skull,

pelvis femora and humeri showed normal appearances *Urine*—Trace of albumin moderate ... pus cells with B coli and B proteus *Blood*—Red blood cells 4 320 000 per c mm Haemoglobin ... cent White blood cells, 18,000 per c mm *Differential leucocyte count*—Polymorphs 75 per cent lymphocytes 20 per cent monocytes 4 per cent eosinophils, 1 per cent, basophils 0 per cent *Plasma chlorides*—341 mgm per 100 c c as chlorine or 562 7 mgm per cent as sodium chloride *Plasma proteins*—6 75 gm per 100 c c albumin 4 4 gm per 100 c c globulins 1 95 gm per 100 c c fibrinogen 0 4 per 100 c c *Blood urea*—42 mgm per cent *Serum phosphatase*—acid phosphatase 1 5 units per 100 c c alkaline phosphatase 6 units per 100 c c *Sternal marrow*—Smears showed a normal histological picture no evidence of a deposit of myeloma *Erythrocyte sedimentation rate*—21 mm in one hour (Wintrobe)

Operation—October 23, 1947 Laminectomy was performed with removal of the laminae of the sixth seventh and eighth dorsal vertebrae A soft friable vascular neoplasm was found eroding the laminae and extending into the erector spinae muscles The neoplasm surrounded the dura mater but did involve its posterior aspect The spinal cord was seen to pulsate Part of the neoplasm was removed

FIG 3

Part of the thoracic spine seen from the front There is collapse of the vertebral bodies and extension of the growth over the heads of the ribs and intercostal spaces

for microscopical study and the wound was closed A plaster support was applied to the ... *Microscopic examination of tissue removed*—The tissue consisted of compact masses of characteristic plasma cells which gave a clearly defined and typical reaction with Unna-Pappenheim methyl green pyronin The tumour was a plasmocytoma

Subsequent history—The general health continued to be satisfactory for several months The urinary bladder was drained continuously with an indwelling urethral catheter until reflex micturition was established six weeks after operation There was complete anaesthesia with paraplegia below the level of the seventh and eighth dorsal vertebrae and five weeks after operation increasing involuntary movements developed in the legs These were partly controlled by luminal and codeine The patient also complained of severe girdle pains In March 1948 his general health deteriorated and he died on April 10 1948

Necropsy—*Viscera*—The brain meninges, tongue, tonsils nasal cavities, pharynx, larynx trachea, thyroid heart oesophagus stomach intestines liver, pancreas spleen, adrenals, kidneys, testes and the lymph nodes throughout the body showed no significant abnormalities The lungs showed severe purulent bronchitis and bronchopneumonia with overlying pleurisy of the lower lobes The bladder showed a moderate degree of cystitis Extensive sloughing bedsores were present over the sacral region and buttocks *Skeleton*—The bodies of the sixth and seventh dorsal vertebrae were completely replaced by soft grey-pink growth with collapse of the bone and free lateral mobility of the spine at this level (Figs 3 and 4) The intervertebral disc between the two vertebrae was largely intact and lay loosely isolated in the centre of the tumour The growth had spread anteriorly and laterally beneath the anterior common ligament and over the ribs and intercostal spaces for a distance of 3 5 centimetres on both sides of the vertebrae It had narrowed the spinal canal and compressed the cord but had not penetrated through the dura mater Posteriorly there was invasion of the dorsal spinal muscles especially on the right side No other tumours were found after careful search in other vertebrae ribs, sternum, skull pelvis, and shaft of right femur,

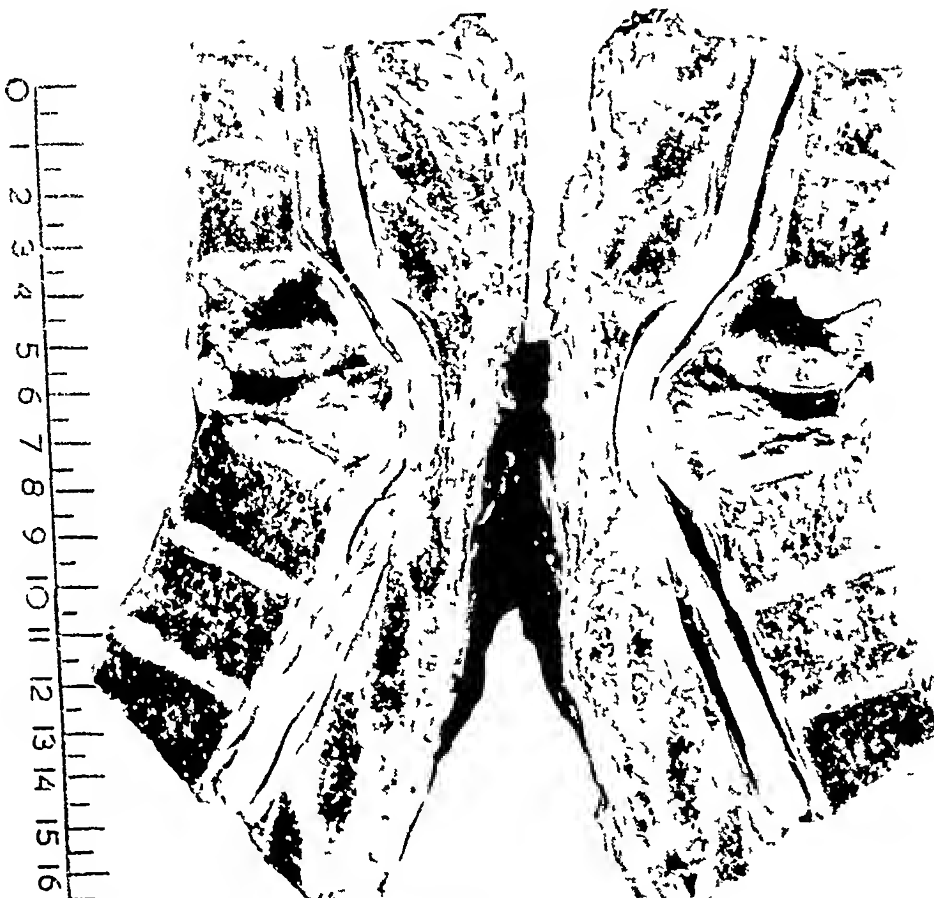

Fig 4

Median section of the spine shows collapse of the affected vertebral bodies which had been replaced by tumour tissue Note compression of the cord and isolation of the intervertebral discs

all of which were sectioned The shaft of the femur contained red marrow from which smears were taken *Histo pathology*—Smears and sections of the vertebral tumour, stained by the usual haematoxylin methods and by the Unna-Pappenheim method for plasma cells showed it to be a typical plasmocytoma with many cells of poorly differentiated immature type but also many well-differentiated plasma cells with characteristic structure and staining properties (Fig 5) The cells showed a moderate number of mitotic figures A few cells were abnormally large and contained large irregular or multiple (usually only two or three) nuclei Stromal tissue was scanty Small blood vessels were plentiful in some parts and there were areas of haemorrhage and degeneration especially in the central regions of the tumour Sections and smears of the red marrow from other bones showed no evidence of plasma-cell infiltration In sections of the kidney a few tubules contained some brownish amorphous debris, probably of no special significance

DISCUSSION

Clinical aspects—The first symptoms of solitary plasmocytoma of bone may arise in consequence of pathological fracture after trivial injury, or pain may occur at the site of the lesion The pain is often severe and, when the lesion is situated in the spine, there may be girdle pain Paraplegia with all its accompanying features is a complication of solitary plasmocytoma of the spine General symptoms occur later and include weakness with secondary anaemia

The radiographic appearances may be grouped into two distinct types In one type there is a markedly destructive lesion involving the bone, the process being well demarcated and sharply defined In some respects it resembles a carcinomatous metastasis of the osteolytic variety or the osteolytic type of osteogenic sarcoma The other type has a cystic and trabeculated appearance, the trabeculae being thickened and irregular The lesion is large, situated in the medulla of the bone, often expanding the cortex

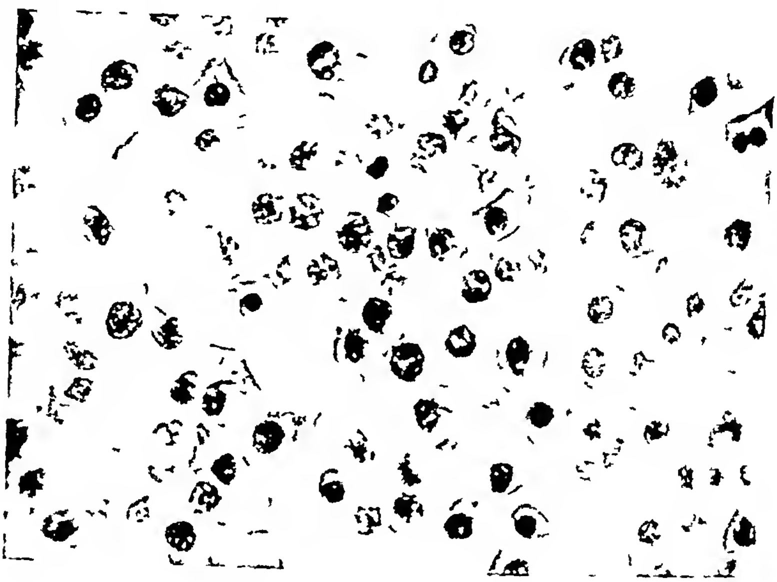

FIG 5

Photomicrograph of section of tumour (× 500)

These solitary tumours are known to be radiosensitive and after high voltage X-irradiation there may be regression with recalcification When the tumour is situated in a site such as the spine this is the best method of treatment, pain is relieved even after vertebral collapse with paraplegia Nevertheless, although irradiation may control the disease for a time there is no evidence that it is curative Surgical treatment has been undertaken for certain tumours situated in accessible sites Thus curettage of the tumour has been performed and subsequent bone grafting undertaken In other cases amputation has been performed If the tumour is situated in the spine, and pressure paraplegia supervenes laminectomy may be required to relieve pressure on the spinal cord

Pathological aspects—In 1941, one of us (R A W) reported a necropsy case of solitary plasmocytoma of the second cervical vertebra and reviewed examples of solitary plasmocytoma of bone that had been reported previously Of these, thirteen were accepted as truly solitary, namely those described by Shaw (1923), Walthard (1924), Zdansky (1927), Martin *et al* (1928), Rogers (1930), Stewart and Taylor (1932), Harding and Kimball (1932), Rutishauser (1933), Chesterman (1936), Cutler *et al* (1936, Nos 17 and 18), Leedham-Green *et al* (193-) and Willis (1941) It was emphasized that a precocious lesion of generalised myelomatosis might appear clinically to be solitary for some months A tumour can be accepted as truly solitary, therefore, only if no further tumours appear and careful radiographic examination

of the rest of the skeleton remains negative for at least one year thereafter Alternatively, adequate necropsy examination may prove the solitary nature of the growth, as in the present case and the one reported earlier Several reported cases that failed to fulfil these requirements were rejected as not being certainly solitary

Review of recent reports in the literature—Certain relevant reports have appeared, or have come to our notice since the 1941 review was made Pasternack and Waugh (1939) reported a solitary plasmocytoma of the upper end of the humerus in a man forty-six years old the tumour had been present for six years, radiographs of the whole of the rest of the skeleton were negative, there was no Bence-Jones proteosuria, and the patient remained well fifteen months after resection of the growth

King (1940) described an instructive case in which a large, apparently solitary, plasmocytoma of the femur proved to be the forerunner of generalised myelomatosis four years later Paul and Pohle (1940), under the title "solitary myeloma of bone," described five cases which however had little claim to that designation two of them showed multiple lesions six and eight months later, and the total periods of observation of the other three were only nineteen, four and eight months respectively Kirsch (1941) reported a plasma-cell tumour of the femur in a man aged forty-six years in whom radiographs twelve years later showed a lesion in a rib, although this was not proved to be a plasmocytoma, its existence prevents us from regarding the femoral tumour as solitary Brehant (1941) reported as a case of "plasmocytome solitaire du tibia" a patient who showed Bence-Jones proteosuria, whose other bones were not examined radiographically, and whose history included no follow-up Esposito's (1943) diagnosis of "solitary myeloma of the skull" applied to a man aged sixty-nine years who was under observation for only five months

Gootnick's (1945) Case 1 was a man aged forty-eight years, in whom a plasmocytoma of the ilium was treated by curettage and irradiation, there was no radiographic evidence of generalisation over four years later Gootnick's Case 2 was a man aged sixty-eight years with a plasmocytoma of the ilium treated by irradiation, the patient died of prostatic carcinoma nearly five years later without evidence of myelomatosis (but there is no mention of radiographic examination of the rest of the skeleton)

Schwartz's (1945) paper is mentioned here only as a warning against confusion of nomenclature that should now be extinct in his paper, entitled "solitary myeloma of the frontal bone," he cited previously reported cases of plasmocytoma, and then reported a case of giant-cell tumour Tennent (1945) described a large plasmocytoma of the ilium in a male patient aged fifty years in whom radiographs of the rest of the skeleton showed no other lesion but who was readmitted two years later with generalised myelomatosis and Bence-Jones proteosuria Blum's (1947) case of "solitary myeloma" has no claim to that title, the patient died five days after hemipelvectomy for a plasmocytoma of the ischium

The recent paper by Lumb and Prossor (1948) is a useful review of the subject of plasma-cell tumours, and includes three cases of interest in the present connection One of these, number 6, showed the first signs of multiple lesions four years after the first symptoms of a large spinal plasmocytoma Case 7 was a man aged forty-eight years who had a plasmocytoma of the upper end of the femur treated by irradiation, who showed no sign of any other tumours radiographically, and remained well for over two years after the first onset of symptoms Case 8 (also published by Lumb, 1948) was of special interest in that a large solitary plasmocytoma of the sacrum in a man aged seventy-two years (proved solitary by later necropsy) was accompanied by Bence-Jones proteosuria and protein blockage of the renal tubules, a complication hitherto described only in cases of myelomatosis

From the foregoing review it will be evident that too many cases of plasmocytoma are still being claimed as "solitary" on unsubstantial grounds This diagnosis can be accepted only if, after the onset of the supposedly solitary growth, there is a long period of freedom from clinical and radiographic evidence of myelomatosis, or if thorough necropsy proves

that no other tumours are present in the skeleton The length of time that must elapse before a patient with an apparently solitary growth can be declared free from risk of generalisation is uncertain While most cases of myelomatosis show their multiple character within a year of the onset of a seemingly solitary tumour, there are occasional cases (such as those of King, Tennent, Lumb and Prossor, Case 6, and possibly that of Kirsch) in which evidence of myelomatosis does not appear for several years In spite of these exceptional cases, there is no doubt from available records that truly solitary plasmocytoma of bone is an entity distinct from myelomatosis, and that it can be cured by adequate local treatment. To those cases accepted as solitary by Willis in 1941, may be added those of Pasternack and Waugh (1939), Gootnick (1945, Case 1), Lumb and Prossor (1948, Cases 7 and 8), and the present case This would bring the total number of accepted cases up to eighteen Of these five had vertebral tumours (Walthard, Cutler *et al*, Willis, Lumb, Raven and Willis) It is noteworthy that fifteen of the total eighteen cases, including all those with spinal tumours were men

TABLE I

SOLITARY PLASMOCYTOMA OF BONE—CASES REPORTED IN THE LITERATURE

Author	Sex	Age	Site of Tumour
Shaw	M	29	Humerus (shaft)
Walthard	M	55	Spine (C 7 and T 1)
Zdansky	F	68	Femur (upper third)
Martin *et al*	F	56	Femur (upper third)
Rogers	M	34	Femur (shaft)
Stewart and Taylor	M	34	Humerus (upper third)
Harding and Kimball	M	60	Femur (upper third)
Rutishauser	F	62	Femur (upper third)
Chesterman	M	39	Tibia (shaft)
Cutler *et al* (Case 17)	M	58	Pelvis
Cutler *et al* (Case 18)	M	52	Spine (L 2)
Leedham-Green *et al*	M	56	Pelvis
Willis	M	45	Spine (C 2)
Pasternack and Waugh	M	46	Humerus (upper third)
Kirsch	M	46	Femur
Gootnick (Case 1)	M	48	Pelvis
Lumb and Prossor (Case 7)	M	48	Femur (upper third)
Lumb and Prossor (Case 8)	M	72	Sacrum
Raven and Willis	M	56	Spine (T 6 and 7)

It should be added that in cases such as the one now reported, in which after a brief history careful necropsy reveals only one tumour, there is no certainty that, had the patient survived longer, the tumour would have remained solitary Only one tumour is present now but multiple lesions might have developed subsequently, since myelomatosis is a multifocal systemic disease In such cases, then, we cannot know whether the tumour is merely the precocious forerunner of the systemic disease or a true instance of the distinct entity solitary plasmocytoma The second alternative is perhaps the more probable

SUMMARY

1 A case of solitary plasmocytoma of the thoracic part of the spine, verified by necropsy is described

2 A brief review is given of eighteen acceptable cases of solitary plasmocytoma of bone

3 Of the eighteen patients, fifteen were men, the five spinal tumours were all in men

4 Diagnosis requires *a*) biopsy identification of plasmocytoma, *b*) exclusion of the possibility of generalised myelomatosis by complete radiography of the skeleton, repeated if necessary at intervals during the ensuing two or three years or longer

5 A tumour of brief duration, proved to be solitary by careful necropsy, cannot be placed with certainty in the group of truly solitary plasmocytomas, it might have been a precocious first lesion of myelomatosis

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We are indebted to Miss Irving-Gass for photographs of the specimen and to Mr Cowles for the photomicrograph

FRACTURES OF THE DORSO-LUMBAR SPINE

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This paper is based on a study of 166 fractures or fracture-dislocations of the dorso lumb spine occurring in 152 miners during the six-year period ended in 1945 One of the objects the analysis was to investigate the relationship between anatomical and functional results in other words to examine the validity of the assumption that a good anatomical result indispensable to a good functional result This assumption was the basis of the teachi of Bohler (1935) which influenced the practice of most continental clinics, it w reiterated in recent American writings by Key and Conwell (1946), and it has been support in Great Britain by so great an authority as Watson-Jones (1943) in the words "perfe *recovery is possible only if perfect reduction is insisted upon*, even *slight degrees of wedgir* of the vertebrae may cause persistent aching pain " Nevertheless an assumption i remains, and an assumption that has the most vital repercussions on treatment The f that it is held so widely and authoritatively is yet another reason for submitting it to card and critical examination

The assessment of deformity is a matter of precision, involving measurable criten The assessment of function, however, is based on criteria that are subject to individu judgment rather than precise measurement Because of the importance of the hypothesis to l examined it seemed necessary to impose an exacting standard for the estimation of functi and certain safeguards were therefore observed 1) no case was assessed in less than tw years, and the average follow-up was five years—long enough to include both late improv ment and late complications, 2) the measurement of such physical properties as mobility muscle power is straightforward but the assessment of pain, which is the most import limiting factor in function, is much more difficult However, the fact that all these patier were miners provided a satisfactory solution, namely, their ability to withstand t conditions of stress that arise in working at the coal-face in cramped positions No patie was classified as having gained a perfect functional result unless he could work und these conditions without discomfort and had, in fact, done so for a number of years

MECHANISM OF INJURY

All the injuries were due to direct violence, usually severe enough to cause contu and tenderness of the erector spinae muscles, a factor that is of significance in relati t treatment and residual pain The usual mechanism was hyperflexion which is al associated with a forward shearing stress The patient was "buried" by a fall of roof coal with his head between his knees If the main force falls on the shoulders, the dor lumbar region receives the greatest strain, but if the force is applied lower down, the lum or lumbo-sacral regions are involved If the knees are extended at the time, the pelvi fixed by the tight hamstring muscles and there is much greater stress at the lumbo s region This was noted in two cases of traumatic spondylolisthesis at this level *In* cases, forward flexion was combined with twisting to one side and this was asso particularly with fractures of the laminae and with the variety of fracture to be de crib later as "lateral wedge fracture" There were no examples of extension fracture which mi be very rare indeed in the dorso-lumbar region, though not so rare in the neck

Level of injury—Table I shows the distribution of fractures at different levels Cer injuries and isolated fractures of the sacrum were *not included*

The distribution does not differ materially from that which has been recorded by other writers The important point to note is that 66 per cent of the injuries were confined to three vertebrae—the twelfth dorsal, first lumbar and second lumbar

TABLE I

Level of Injury in 166 Fractures occurring in 152 Patients

Level of fracture	Number of cases	Percentage of total
Dorsal 10 and above	7	4 2
Dorsal 11	12	7 2
Dorsal 12	34	20 5 } 66 4
Lumbar 1	49	29 6 }
Lumbar 2	27	16 3 }
Lumbar 3	17	10 2
Lumbar 4	12	7 2
Lumbar 5	8	4 8
Total	166	100 0

Number of cases with multiple fractures=14 (9%)

Type of fracture—The fractures were classified on an anatomical basis into four main types anterior wedge fracture, lateral wedge fracture, fracture-dislocation, and isolated fracture of the neural arch (Table II) This differs from the classification adopted by Watson-Jones (1943) who did not differentiate lateral wedge fractures or isolated fractures of the neural arch, and believed that comminuted wedge fractures were relatively common (15 per cent)

TABLE II

Types of Fracture

	Number of cases	Percentage
Anterior wedge fracture	88	58
Lateral wedge fracture	21	14
Fracture-dislocation	29	19
Isolated fractures of the neural arch	14	9
Total	152	100

Anterior wedge fracture—The extent of wedging varies, but in half the cases it is minimal It cannot, in fact, be severe without involving the posterior interspinous ligament since the fulcrum of movement is at the nucleus pulposus of the intervertebral disc (Figs 10 and 11) If this fulcrum remains intact, and wedging is severe, rupture of the ligament with subluxation of the posterior intervertebral joints is inevitable This can often be demonstrated in good radiographs, or it can be inferred from the undue separation of spinous processes Many so-called wedge fractures with severe wedging are, in fact, fracture-subluxations in which the inferior facets of one vertebra are displaced upwards or even "perched" on the superior facets of the other (Fig 15) The importance of recognising this lies in the fact that it is an unstable position which is easily converted into a fracture-dislocation with forward displacement of the vertebral body and possible damage to the cord, whereas cases with minimal or moderate wedging and an intact posterior interspinous ligament are quite free from this danger

There is a special type of anterior wedge fracture in which the whole of the vertebral body is more evenly compressed This "concertina" type of compression occurs in older people and there is little or no angulatory deformity As a rule it is associated with

degenerative changes in the nucleus which fails to act as a fulcrum The interspin ligament remains intact and vertical compression occurs

Wedge fracture with comminution—These cases are stated by Watson-Jones to constitu 15 per cent of all spinal fractures and to be associated especially with the type of direc violence that occurs in mining accidents Since this was the mechanism responsible for cases in the present series it would have been reasonable to expect a higher incidenc even up to 30 per cent , but in fact only eight cases were seen in simple wedge fractur (Figs 1 and 2) Comminution is much more often seen in fracture-dislocations Its importance in association with wedge fractures lies in the fact that it has been put forward as an explanation of late redisplacement which will be discussed later

Fig 1

Fig 2

Vertical compression fracture showing comminution of the vertebral body and slight retropulsion There is also an anterior wedge fracture of L 1 without comminution (Fig 1) The compression was reduced and after six months immobilisation in plaster the comminuted body healed well There was no collapse but the disc spaces above and below are narrowed and spontaneous fusion is occurring (Fig 2) This is often the case when there is comminution

Lateral wedge fracture—This is a type of vertebral fracture that has not been described in previous classifications It constitutes 14 per cent of the present series and has certa anatomical and clinical characteristics that appear to justify its differentiation It is a flexion-rotation injury, the usual history being that the patient's head is forced forwards and to one side The unilateral wedging, the associated fractures of transverse processes on the convex side, and the damage to the posterior intervertebral joint on the concave side should be noted (Figs 3 and 4)

Certain clinical features are specially associated with this fracture 1) The progno is not good, in this series only 21 per cent gained complete functional recovery as against 4? per cent in anterior wedge fractures 2) Residual pain, if present, is commonly at the site of fracture (93 per cent) whereas in anterior wedge fractures pain is usually at the fifth lumb level regardless of the site of fracture (72 per cent) The pain in lateral wedge fractures is related either to the displaced intervertebral joint which may also involve the nerve root, or to tearing of the ilio-psoas muscle as indicated by associated fractures of the transver processes which usually show wide separation, indicating severe damage to the soft ti Retroperitoneal haemorrhage is not uncommon and may present all the signs and sympto of an acute abdominal catastrophe Two patients in this series with lateral wedge fractu

were submitted to laparotomy, with negative findings (Fig 3), before the spinal condition was diagnosed 3) These fractures are difficult to reduce In fact, reduction was achieved only three times in twenty-one patients, in two of the three there was redisplacement, and the only good anatomical result was secured by grafting 4) Damage to the cord may occur in lateral wedge fractures whereas there was no such damage in any anterior wedge fracture in this series There were two paraplegias in twenty-one cases of lateral wedge fracture and both failed to recover The probable explanation is that the cord and cauda equina are tethered laterally by the nerve roots and dentate ligament, so that lateral flexion is more liable to tear the cord than simple forward flexion This is supported by the fact that in the two cases mentioned above, paralysis was greater on the side opposite the wedging

Fig 3

Lateral wedge fracture with retroperitoneal haemorrhage simulating acute abdomen If this radiograph had been taken twenty-four hours earlier a fruitless laparotomy might have been avoided

Fig 4

Lateral wedge fracture in which there was spontaneous bone fusion There was considerable deformity but nevertheless the functional result was perfect

Fracture-dislocation—The essential difference between a fracture-dislocation and a simple wedge fracture lies in the fact that in fracture-dislocation there is rupture of the posterior interspinous ligament Several degrees of displacement may be distinguished such as simple upward subluxation of the facets, " perching " of the facets, forward dislocation with fracture of the facets or neural arch, and forward dislocation with locking of the facets All these can be reduced by manipulation except the last, in which manipulation is dangerous It is important, therefore, to distinguish between them before attempting manipulation and this calls for radiographs of the very best quality A test reduction may be carried out by turning the patient carefully into the prone position and repeating the lateral view If there is no reduction in the amount of forward displacement it may be inferred that the facets are locked Damage to the cord or cauda equina is very frequent in fracture-dislocations (62 per cent in the present series) There were twenty cases of paraplegia, eighteen associated with fracture-dislocations, and two with lateral wedge fractures

FIG 5

Traumatic spondylolisthesis Closed reduction failed and the patient refused operation Plaster bed six months After two years there was spontaneous arrest but the patient still had referred pain in both lower limbs

FIG 6

Fracture of the lamina of the second lumb vertebra After three years although there only fibrous union forward sliding is minim There is no disability and the patient wor at the coal face

FIG 7

FIG 8

Fracture of lamina of third lumbar vertebra This patient was not seen until six weeks after injury and that time he had been walking about Note that there has been no forward sliding (Fig 7) Three ye there is still no forward sliding and union has occurred (Fig 8) The patient is now working at the co

Neural arch fractures—These are rotation injuries, as shown by the fact that half of them are associated with fractures of the transverse processes. They are often described wrongly as fracture of the pedicles—an extremely rare injury which probably never occurs except as part of a severe fracture-dislocation The site of fracture is at the interarticular part of the lamina so that when there is displacement, as in the bilateral variety, the superior facet slides forwards and the inferior facet remains behind, as in the classical type of spondylolisthesis (Fig 5)

In bilateral laminar fractures the level of injury is important If it occurs above the fourth lumbar vertebra the tendency to slide forwards is minimal (Fig 6) The patient illustrated in Figure 7 was not seen until six weeks after injury, during which time he had been walking about He was then treated by simple recumbency after which union occurred readily with no further displacement

At the level of the fourth or fifth lumbar vertebrae the story is quite different, for it is here that body-weight exerts a forward shearing stress If a bilateral laminar fracture is overlooked at this level (and it is quite easy to do this) forward sliding is bound to result, with consequent spondylolisthesis The most perfect X-ray films are needed and suspicion should always be aroused if there is a fractured transverse process at this level

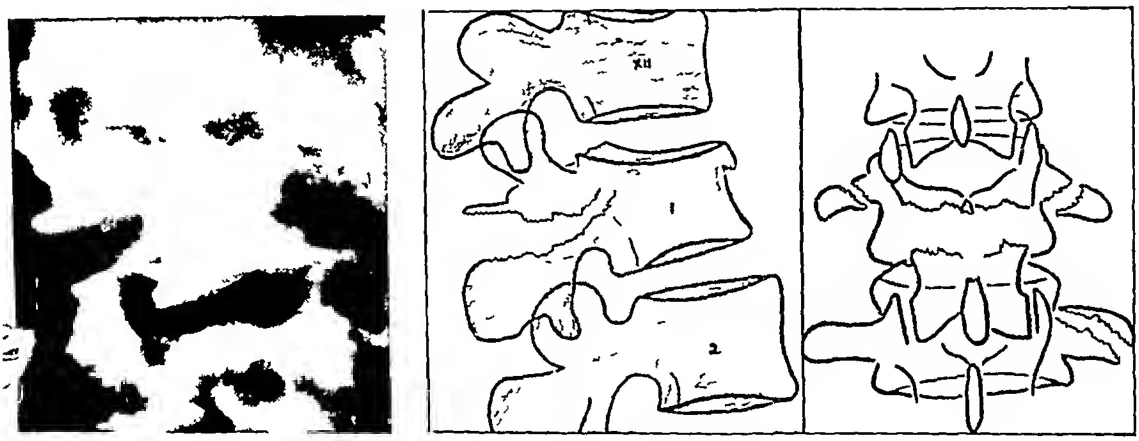

FIG 9

Chance s fracture through the spinous process laminae and vertebral body

A special type of laminar fracture has been described recently by G Q Chance (1948) In this, the fracture line is horizontal and is continued anteriorly into the body and posteriorly into the spinous process (Fig 9) There may be slight wedging but since the fracture line passes through bone all the way, and there is no subluxation of the facets, or rupture of the posterior ligament, reduction is followed by bony union which is stable As Chance points out, failure to recognise these cases may lead to unnecessary grafting operations

REDISPLACEMENT AFTER REDUCTION

Redisplacement after reduction and prolonged immobilisation is more common than is generally supposed Stanger (1947), reviewing a series of fracture-dislocations of the spine several years after injury, found that deformity had recurred in a high proportion of cases The same is true of simple wedge fractures and, in the present series, it was the exception rather than the rule for a good anatomical result to be maintained in any case in which initially there had been more than minimal deformity In the earlier years of the period covered by this review great pains were taken to maintain complete reduction in plaster, sometimes for six months, only to see deformity recur, very often within a month of removing the plaster The questions that arise are whether the factors responsible for such

redisplacement can be recognised at the outset, and whether a perfect anatomical result i
fact an indispensable objective in treatment

Mechanism of flexion-extension movement in the normal spine—It is necessary
to consider the mechanism of flexion and extension in a normal spine The fulcrum of
movement is not at the interarticular joints but at the nucleus pulposus of the intervert
disc (Calve and Galland 1930) Normally, the posterior part of the disc space actually narr
in hyperextension, proving that this point is behind and not in front of the fulcrum (Fig 11
If the fulcrum remains intact, any degree of hyperflexion capable of producing even minim
wedging of the vertebral body exerts great leverage on the interspinous ligament
hyperflexion proceeds still further, rupture of the ligament is inevitable, there may be
avulsion fracture of the spinous process, and a varying degree of subluxation of the fac
depending upon the degree of separation of the spinous processes This is the sequence
events if the fulcrum remains intact, but in many cases the interspinous ligament is th
stronger of the two and the disc itself is crushed

Fig 10

Fig 11

The normal mechanism of spinal movement Fig 10 shows the intervertebral joint in full flexion and Fig 11 in full extension The fulcrum is at the nucleus pulposus

Thus, four structures are involved—the vertebral body, the disc, the intervert
joints and the interspinous ligament Each of these should be considered separately when
the radiographs of an injured spine are examined Furthermore, the erector spinae mu
may be overstretched or partly ruptured

Factors concerned in redisplacement after the reduction of vertebral fractures—
The three most important factors concerned in redisplacement can now be considered T
are comminution of the vertebral body, crushing of the intervertebral disc, and ruptur
the interspinous ligament

Comminution of the vertebral body—Comminution is comparatively rare in simple we
fractures When it occurs, consolidation is delayed, as pointed out by Watson-Jones (19
However, the vertebral body has a good blood supply (evidence of avascular necro
observed only twice in the present series) and in about half the patients consolidation of b
in the fully reduced position can be achieved, but the price to be paid is six months in pl
(Fig 2) Comminution, however, is almost invariably associated with damage to the d
the interspinous ligament, or both, in which case some collapse is inevitable whatever happ
to the vertebral body

Crushing of the intervertebral disc—This is much more common than is often suppo
can be recognised in the original radiograph by narrowing of the disc space (Fig 12) th
after reduction, the space may appear to be normal (Fig 13) Sometimes the disc can b

FIG 12

FIG 13

FIG 14

Vertebral fracture with almost complete disappearance of the disc space indicating that it has been damaged irretrievably (Fig 12) The disc has no blood supply and is incapable of repair so that deformity is inevitable Perfect anatomical reduction was maintained for six months (Fig 13) Nevertheless recurrence of deformity was inevitable—and the inevitable happened three months after removal of the plaster the disc space collapsed again (Fig 14)

FIG 15

FIG 16

FIG 17

Often wrongly diagnosed as a wedge fracture with severe deformity (Fig 15) It is in fact a fracture-subluxation with perching of the facets and rupture of the interspinous ligament This is an unstable type and should have been grafted It was fully reduced and immobilised in plaster (Fig 16) But deformity will recur however long this position is maintained because the interspinous ligament is ruptured Two years later (Fig 17) deformity has recurred

to have prolapsed into the vertebral body and to have remained there after reduction Lastly, damage to the intervertebral disc may be recognisable only many months later by thinning of the disc space or spontaneous anterior fusion When the disc is damaged, redisplacement is inevitable, for the disc has no blood supply and it is incapable of repair Some residual deformity must therefore be accepted and it is not only futile to immobilise damaged soft tissues in an extreme position for long periods in the hope of achieving what is, in fact, impossible, but it is actually harmful to do so Occasionally, crushing of the disc into the body of the vertebra may cause retropulsion of the posterior part of the vertebral body into the spinal canal (Fig 1)

Rupture of the interspinous ligament—This ligament may be overstretched, partly torn or completely ruptured, with or without avulsion-fracture of the spinous process. The significance of these findings is exactly the same as in the case of injuries of the medial collateral ligament of the knee joint. Overstretching and incomplete rupture are compatible with sound healing and restoration of stability, but a completely ruptured ligament seldom heals unless it is sutured. In the case of the spine, it is easier to fuse the spinous processes than to suture the ligament. The degree of damage can be estimated by the amount of separation of the spinous processes in lateral radiographs. In the case illustrated in Figure 1 complete reduction was maintained for six months but nevertheless subluxation recurred within one month of removing the plaster, though not to the original extent.

ANALYSIS OF END-RESULT DISABILITY

1) **Pain**—In this series all the patients were miners and their capacity for work, involving considerable physical stresses and the adoption of cramped positions, was a searching test of function. *The miners of Great Britain have special rehabilitation centres, situated in each* coalfield, staffed by experienced orthopaedic surgeons and providing a high standard medical and social service. Spinal injuries are thirty-five times more common in miners than in the rest of the community and as consulting surgeon to this service I have had the opportunity of observing the work of all my colleagues throughout the mining areas.

It has been a universal experience that even the most exacting and prolonged tests in rehabilitation centre are not equivalent to the functional test of work at the coal-face. Many patients discharged from a rehabilitation centre in the highest grade of recovery fail to stand up to the demands of full work. The reason is always the same—pain returns under the particular conditions of stress and posture that are involved in actual work at the coal face. Other factors such as mobility, muscle power and muscle endurance are important, but pain under stress is the crucial factor, and as an end-result symptom it calls for detailed analysis. It should perhaps be repeated that no cure was accepted as complete unless the patient had done full work for two years without disability—so that the conclusions may be accepted with some assurance.

TABLE III

ANALYSIS OF 89 CASES WITH RESIDUAL PAIN

Site of pain in relation to type of fracture

Type of fracture	Number of cases	Pain at site of fracture	Low back pain
Anterior wedge fracture	58	28%	72%
Lateral wedge fracture	15	93%	7%
Fracture dislocation	7	43%	57%
Fractures of the neural arch	9	33%	67%
Total	89	40%	60%

Pain is of two types: 1) at the site of fracture, 2) in the low back, independent of the site of fracture. Pain at the site of fracture nearly always occurred in patients with lateral wedge fractures. Of patients who sustained such fractures and had residual pain the localisation was to the site of fracture in 93 per cent (usually towards the side of wedging), whereas in patients with residual pain after anterior wedge fractures it was localised to the site of fracture in only 28 per cent.

In patients with residual pain after anterior wedge fractures, low back pain is the rule. It occurred independently of the site of fracture in 72 per cent of these cases. The characteristic features were that it was eased by complete rest, brought on by prolonged sitting or standing, eased by moderate exercise, and brought on again by severe exercise or prolonged forward

stooping These findings suggest a soft tissue pathology rather than a bone or joint pathology They are, in fact, identical with those found in cases of low back pain resulting from sprains and contusions and it is probable that they are due to fibrosis and adhesions occurring in damaged muscles and ligaments immobilised in their shortened position As evidence of this, it was much commoner in patients with anterior wedge fractures treated by hyper-extension plasters (80 per cent) than in those treated by other methods (37 per cent) Every surgeon who has operated on these cases in the early stages is familiar with the extensive haemorrhage that is to be found in the erector spinae muscles This extends to the pelvic attachment, even in high lumbar fractures, because haemorrhage in muscle always tends to gravitate to the most dependent part It is understandable that pain due to subsequent fibrosis should be felt so commonly at the lower attachment of the muscle

2) **Mobility**—Reference must be made to loss of mobility as an end-result symptom if only because it has been overstressed in the past Localised stiffness in the lumbo-dorsal spine causes no appreciable disability, and the test of making the patient bend forwards and put his hands flat on the floor, which is illustrated in many text-books as proof of spinal mobility, is quite fallacious The radiographs reproduced in Figure 19 are of the patient shown in Figure 18, the greater part of the movement is obviously occurring at the hip joints Because

FIG 18

The owner of the spine whose radiographs are depicted in Fig 19

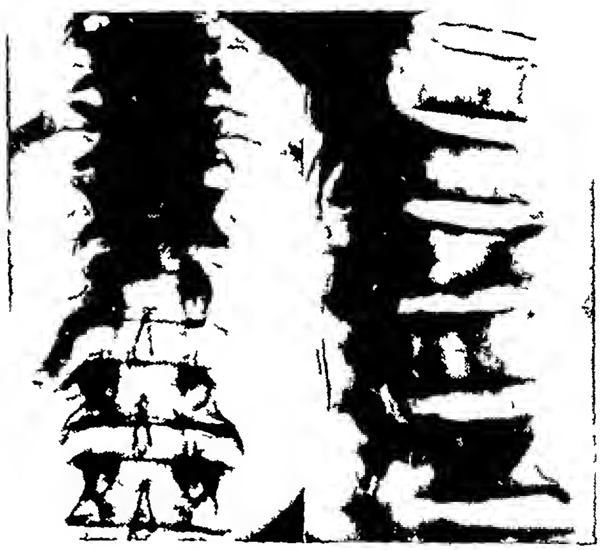

FIG 19

Ability to touch the toes does not mean that the lumbo-dorsal spine is mobile

of their occupational conditions most miners retain the long hamstring muscles characteristic of infancy and can perform this test even with a "poker" back In short, localised fusion of damaged vertebrae, whether the cause be disease or trauma, is the best possible thing that could happen and it causes no significant limitation of movement If there is gross restriction of movement it is usually due to muscle-spasm resulting from pain, and abolition of the pain will restore mobility

3) **Power and endurance**—Whereas mobility is unimportant, muscle power in the erector spinae group is very important The miner depends on the strength and endurance of these muscles for his livelihood These two properties of muscle—power and endurance—must not be confused they are quite distinct, they have a different physiological basis, and they call for a different technique of treatment in rehabilitation (Nicoll 1948) Pain, however, may inhibit the full use of muscles and prevent their full redevelopment These functions of muscle can be measured fairly accurately but in doing so it is important to know whether deficiency is due to actual loss of muscle power, or simply to painful inhibition restricting

full output In the miner, these muscles have to be capable of working at a high level efficiency for eight hours without respite under conditions that are particularly try

RELATIONSHIP BETWEEN DEFORMITY AND DISABILITY

We may now consider the hypothesis, on which present-day orthodox treatment is ba that a good anatomical result is indispensable to a good functional result The hypoth will be examined from two aspects 1) records of individual cases, 2) statistical analysis the whole series It is hoped to show that there are no grounds whatever for the abov assumption

Early in 1940, a miner was admitted to hospital suffering from a supraspinatous cu injury In the ordinary course of examination it was impossible not to notice that he ha a deformed back, and radiographs showed gross deformity (Fig 20) This fracture-dislocati of the spine had been sustained thirty years previously, it had never been diagnosed treated and it had united in the position of deformity, the miner has been complete free from symptoms and has worked at the coal-face ever since This case not only prov that gross deformity is compatible with complete functional recovery, but that there may b no late complications

Fig 20

Thirty years ago this man was injured in a pit accident Treatment was three months in a feather bed" Every other day his back was rubbed with honey — an ancient remedy mentioned in the Edwin Smith papyrus It proved so effective that within a year he was at the coal-face and has worked there ever since

Fig 21

Vertebral fracture resulting in spontaneous fusion in a position of deformity The surgeon was mortified at this terrible result but the patient himself was quite pleased with it because he has no pain and no other symptoms and he has been working at the coal face without interruption for the last five years

Shortly after this patient was seen, another miner was admitted, suffering from t fracture-dislocation shown in Figure 21 He developed pneumonia soon after admission a his general condition was so serious that, for six weeks, any treatment by which to reduce t deformity was out of the question At the end of that time reduction was impossible and th deformity shown in the radiograph had to be accepted as the final anatomical result Th spinous process was so prominent that he developed an adventitious bursa over it and coul not lie on his back in comfort This prevented him from carrying out certain exercises an his treatment at the Rehabilitation Centre had to be interrupted in order to excise the bu and the underlying bony prominence He made a perfect functional recovery and has wo ever since as an underground ripper—very heavy work, equivalent in almost every work at the coal-face

FIG 22

Fracture dislocation of the spine with severe deformity and incomplete paraplegia The vertebral body has split vertically and the spinal cord escaped complete section only by slipping between the fragments Closure of the gap would have been dangerous and over-zealous efforts at reduction might have ended in disaster

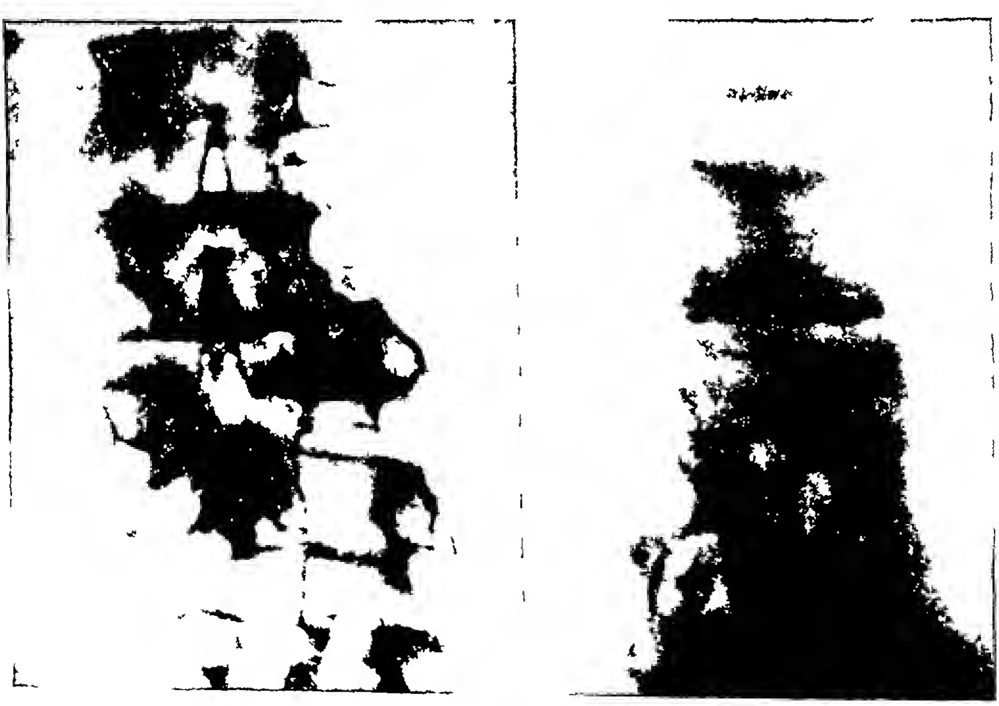

FIG 23

Same case as shown in Fig 22 three years later Spontaneous fusion with marked deformity The paraplegia recovered and the patient went on to achieve a perfect functional result He is now working as an underground ripper

The patient whose radiographs are illustrated in Figure 22 had incomplete parapl There was so much comminution and displacement that complete reduction was impossi Moreover, enthusiastic attempts at reduction might easily have inflicted further dam on the cord which obviously had escaped total section only by a miracle, it was lyi between the two halves of the vertebral body The patient was simply turned into the pr position and a plaster bed was made in which he was nursed for five months The fin anatomical result is shown in Figure 23 He recovered completely from the paraplegia a resumed full work as an underground ripper He has no pain in the back and mobility is n restricted significantly

Lastly, the case illustrated in Figure 24 shows a fracture-dislocation with locking of t facets There was no damage to the cord This patient was seen many years ago, before t locked-facet syndrome was well known or the method of dealing with it understood Natural attempts at reduction failed This man also made a perfect functional recovery and w back to full work at the coal face He continued to do this for four years without sympto until a further accident necessitated arthrodesis of the ankle joint

FIG 24

Fracture-dislocation of the lumbar spine with locked facets in which stabilisation was achieved spontaneously in the unreduced position The patient gained a perfect functional result This radiograph was taken five years after injury

FIG 25

Anterior wedge fracture with minimal deformity and no damage to the disc o rupture of interspinous ligaments Orthodoxy would demand three months in plaster Fortunately the fracture w overlooked and the patient was back at the coal-face within three weeks

These examples, which could be multiplied, show that marked deformity is compatib with perfect function In fact, there were twenty-four patients in the present seri wl achieved perfect function despite residual deformity However, any attempt to refute general hypothesis by quoting individual examples is unscientific It is always possibl th such examples may represent the exception rather than the rule, in which case all that h been proved is that the rule has exceptions A more scientific method is to examine a se of consecutive and comparable cases The results in fifty patients in whom recovery, as ju by the very high standard already noted, was classified as complete are analysed in Tabl I

TABLE IV

ANALYSIS OF THE INCIDENCE OF RESIDUAL DEFORMITY IN 50 PATIENTS WITH PERFECT FUNCTIONAL RESULTS

	Good anatomical result	Residual deformity
Anterior wedge fracture	20	13
Lateral wedge fracture	1	3
Fracture dislocation	1	8
Fractures of neural arch	4	—
Total	26 (52%)	24 (48%)

From Table IV it is clear that the anatomical result is not a significant factor This is also borne out when the group of anterior wedge fractures is analysed separately Of eighty-eight patients in this group, fifty-four showed good anatomical results, of these, twenty (37 per cent) gained perfect functional results Thirty-four patients had residual deformity and, of these, thirteen (38 per cent) gained perfect functional results Table V is an analysis of end-results in relation to treatment, and here a significant factor may be noted

TABLE V

ANALYSIS OF TREATMENT IN RELATION TO END-RESULTS IN 152 PATIENTS WITH FRACTURES AND FRACTURE-DISLOCATIONS OF THE DORSO-LUMBAR SPINE (excluding seventeen patients who died or had irrecoverable paraplegia)

End-result (working capacity)	Fixation in plaster	Functional treatment
Coal-face	23 (27%)	27 (55%)
Light work underground	9 (10%)	13 (27%)
Light work on surface	54 (63%)	9 (18%)
Total	86 (100%)	49 (100%)

Of all patients with dorso-lumbar fractures treated in plaster, 27 per cent were subsequently classified as having gained perfect functional results, whereas, of patients treated by what may be called "functional" methods, 55 per cent achieved a similarly good end-result However, analysis of this kind is not really scientific because it might so happen that cases selected for functional treatment had a type of fracture with an inherently better prognosis The same analysis was therefore made in relation to individual types of fracture (Table VI)

TABLE VI

ANALYSIS OF TREATMENT IN RELATION TO END-RESULTS IN 88 ANTERIOR WEDGE FRACTURES

End-result (working capacity)	Fixation in plaster	Functional treatment
Coal face	10 (20%)	24 (63%)
Light work underground	5 (10%)	8 (21%)
Light work on surface	35 (70%)	6 (16%)
Total	50 (100%)	38 (100%)

It is seen that in the group of anterior wedge fractures 20 per cent of patients treated in plaster were classified as having gained perfect results, whereas 63 per cent of patients treated by "functional" methods gained perfect results In the other groups, the number of

patients treated functionally was too small to justify conclusions, but there was some evidence in the case of fracture-dislocations that plaster applied in the physiological position gave better results than hyperextension plasters Magnus (1931), working in the Ruhr Coalfield came to similar conclusions He found that in patients treated without fixation in plaster the average duration of incapacity was seventeen weeks and the disability compensation 4? per cent, this comparing with twenty-eight weeks and 64 per cent respectively for patients treated in plaster

It is submitted that these findings lead to four conclusions 1) a good functional result is *not* dependent on a good anatomical result, 2) consolidation is rapid even in the absence of fixation, 3) the important factor in determining function is stability between the damaged segments and not the position in which it is achieved, 4) prolonged fixation of damaged soft tissues, especially in their shortened position, is in itself a cause of disability

TREATMENT OF DORSO-LUMBAR FRACTURES

Stable and unstable fractures—When there is no special problem of spinal cord injury the best classification, for purposes of treatment, is into stable and unstable varieties Stable fractures include anterior and lateral wedge fractures and all laminar fractures above the fourth lumbar level Unstable fractures include all fracture-subluxations with rupture of the interspinous ligament, all fracture-dislocations, and all laminar fractures at the level of the fourth and fifth lumbar vertebrae In the stable group there is no danger of the deformity increasing and thereby threatening the cord They should, therefore, be treated "functionally" and not by immobilisation in plaster In these patients the degree of deformity is never great, it causes no functional disability, and it can be disregarded from the cosmetic point of view All such patients treated without plaster fixation were examined radiographically on admission, on discharge, and several years later, and in no instance was there significant increase in the deformity It must be stressed again, however, that nearly all so-called "simple wedge fractures" in which there is severe wedging are, in fact, fracture-subluxations with rupture of the posterior interspinous ligament and are, therefore, unstable

In the unstable group, deformity is likely to increase and it may even endanger the cord The high incidence of paraplegia in fracture-dislocations (62 per cent in the present series) suggests that the cord is always vulnerable in this type of injury Unstable injuries should therefore be protected against increasing displacement until consolidation is well advanced

"Functional" treatment of stable fractures—When functional treatment is adopted no attempt is made either to reduce or immobilise the fracture, but the patient is kept in bed for three or four weeks in order to rest the damaged soft tissues and relieve pain During this period he carries out only extension exercises and receives heat and massage to the back every day to assist the absorption and dispersal of exudates in the muscles and fascial planes After four weeks he gets up, starts a scheme of full exercises, and is transferred to a Rehabilitation Centre At the end of eight weeks he has progressed to the highest exercise grade in the Centre and begins a period of hardening which aims at reproducing the stresses and postural difficulties of underground mining At the end of twelve weeks he should be fit to start work, but often requires another two months on progressively heavy underground work before returning to the coal-face Some patients beat even this timetable whereas orthodoxy would demand that every fracture should be reduced and immobilised in hyperextension for at least four months (Fig 25)

Treatment of unstable fractures—In this series the best results in unstable fractures were gained by applying a "protective" plaster in the neutral or physiological position T...

associated disc or ligament injury makes some degree of residual deformity inevitable The vertebral bodies are, therefore, allowed to approximate in the plaster so that anterior fusion can occur In practice, spontaneous anterior fusion with deformity gives a better functional result than surgical fusion Of ten fracture-dislocations treated on these lines, seven returned to full work at the coal-face, all had spontaneous anterior fusion with deformity and they represent the best results of any group in the present series No patient whose fractured spine has been treated by surgical fusion has ever returned to coal-face work The advantages of spontaneous anterior fusion are that it is both stronger and more localised Posterior fusion is mechanically less sound because the graft is under tension instead of compression Moreover, undamaged vertebrae are usually included in surgical fusion so that four instead of two become fixed

The "double clothes-peg" graft described by Bosworth (1942) has removed some of the above objections, and it is now being used to *supplement* anterior fusion, care being taken not to extend the spine beyond the point at which anterior fusion would be prejudiced by distracting the bodies It is believed that unless there is firm anterior support any posterior graft will eventually give way A recent series of fifteen unstable fractures treated by the Bosworth graft is being followed-up and will be studied with the object of determining whether or not the long-term functional results are better than those gained by spontaneous anterior fusion

Treatment of dorso-lumbar fractures with paraplegia—The primary surgical treatment of traumatic paraplegia is still a matter of controversy In Great Britain a conservative attitude is generally adopted, whereas in the American continent open reduction and grafting is favoured by Rogers, Munro, Botterill, Cone and others Even among those who favour early operation there is a difference of view regarding the indications Some would explore almost every case while others, such as Penfield, would operate only on patients with incomplete paraplegia showing a spinal block On the other hand, Naffziger shares the views of Jefferson, Guttmann, Bohler and others, that paraplegia which is clinically complete from the time of injury and remains so for forty-eight hours indicates that there is complete section of the cord or at least an irrecoverable lesion Guttmann contends that in these circumstances, paraplegia having been accepted as a permanent disability, the spinal injury should be ignored and all efforts be concentrated on the prevention of pressure sores while stabilisation of the spine in the displaced position is achieved Bohler points out that this occurs rapidly and that stability can be gained even sooner than would be the case if reduction and grafting had been carried out However, the premise on which these views are based is not universally accepted and the surgeon who discounts all possibility of recovery within forty-eight hours of injury without the most incontrovertible proof accepts a heavy responsibility

Many surgeons believe that recovery may occur even after lesions which remain complete for several days This writer has seen several examples of late recovery in lesions at the cauda equina level, and at least one in which the cord itself was involved, and if this possibility is accepted the lumen of the neural canal should be restored and the spine stabilised in that position in accordance with the dictum of Rogers of Boston It is generally agreed, however, that any form of plaster fixation, either by means of a plaster cast or plaster bed, is certain to lead to pressure sores so that the maintenance of the reduced position, whether obtained by manipulative methods or by open operation, is difficult In the absence of plaster fixation, reduction can be maintained only by some form of graft or internal fixation which is self-stabilising, the patient thereafter being nursed on a Stryker frame If the spinous processes and neural arches are intact, a self-locking letter-box graft can be used This was adopted recently in two patients who were given no external support and were turned regularly for

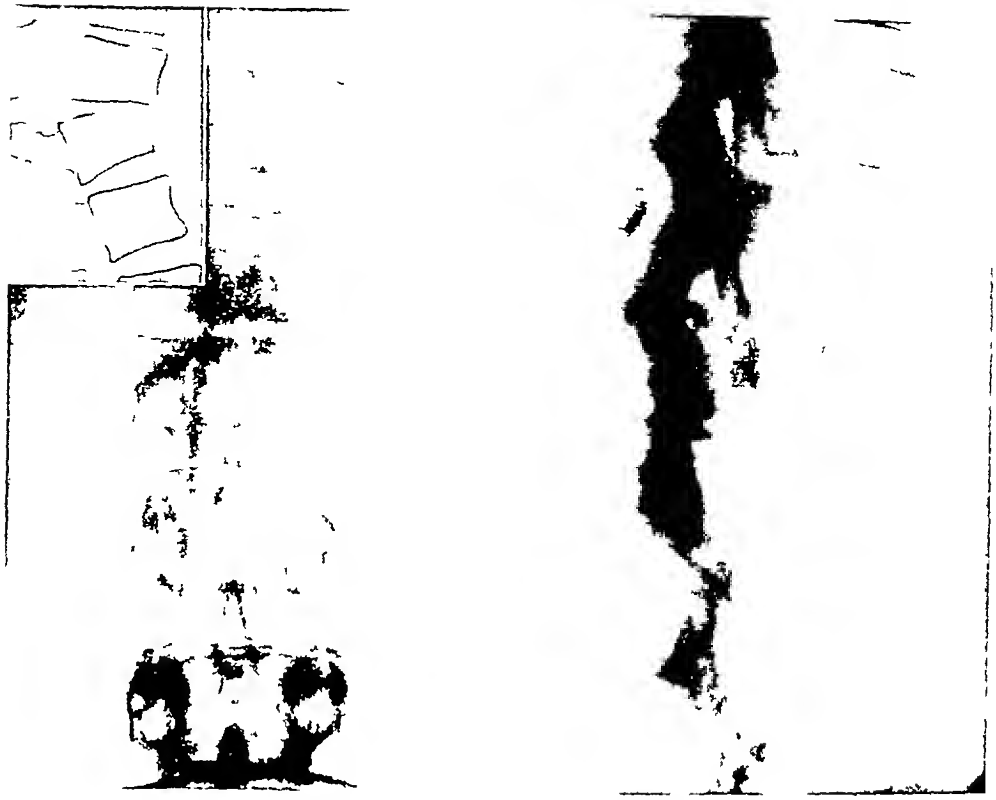

FIG. 26

Fracture-dislocation with paraplegia (inset) treated by self-locking letter-box graft of the spinous processes. No external fixation was used and the patient was turned regularly for nursing care. Ten months later reduction has been maintained and fusion has occurred. Recovery from the paraplegia, in this case, was complete.

FIG. 27

FIG. 28

Traumatic spondylolisthesis (Fig. 27) treated by open reduction and grafting (Fig. 28). This is the *only* way of reducing such cases but it must be done early. Manipulative reduction should not be attempted because it is (*a*) impossible, (*b*) dangerous.

nursing care, reduction was maintained until fusion occurred and pressure sores were avoided (Fig 26) All such methods of self-locking graft depend, however, on the integrity of the posterior neural arches and facets In three recent cases (one seen by the courtesy of Mr Gordon Irwin of Newcastle) there was such disruption of the neural arches that neither manipulative nor operative reduction could have succeeded in restoring the lumen of the spinal canal and decompression by laminectomy appeared to be justified, especially when there was evidence of spinal block The primary treatment of traumatic paraplegia is obviously a subject about which there is still much to be learned, and in the present state of our knowledge any dogmatic recommendation is unjustified

Treatment of isolated fractures of the neural arch—The treatment of fractured laminae depends upon the level of injury and the stage at which the case is first seen Many of these fractures are overlooked because they demand a very high standard of radiography, especially in the lumbo-sacral region It has already been stated that above the level of the fourth lumbar vertebra there is no danger of forward sliding beyond minimal limits so that these cases can safely be treated by functional methods In the present series there were six such cases and four were classified as complete cures If the lesion is at the fourth or fifth lumbar level, treatment depends upon whether or not there is spondylolisthesis If not, union will probably occur with four months' immobilisation on a plaster bed, but if forward sliding has already begun, union is unlikely to occur because the conditions resemble those of a gap fracture Open reduction and fusion is then the best treatment The method of closed reduction advocated by Watson-Jones (1943) was tried twice but there was no improvement in the position and in one case a temporary foot-drop resulted

In the present series, there were eight patients with fractures of the laminae at the low lumbar level and of these, six had already begun to slide when first seen Progressive displacement was prevented in all of them by grafting but none was able to resume strenuous underground work because of low back pain under stress, though all were able to do lighter forms of underground or surface work The best result was in one whose fracture of the laminae was not displaced but failed to unite after immobilisation in a plaster bed Operation was then undertaken and fusion occurred in a good anatomical position From the total of fourteen cases at all levels, there were only five perfect results and all these were good anatomical results It does seem, therefore, that in this particular type of fracture a good anatomical result is essential Recently, a case of traumatic spondylolisthesis with considerable immediate displacement was seen and operated on within a few days It was possible to secure complete reduction and this has been maintained (Figs 27 and 28) It is now considered that this is the *only* way of obtaining reduction in these cases, but it must be done early

Treatment of lateral wedge fractures—Lateral wedge fractures present a difficult problem in treatment Of the twenty-one examples in the present series two were complicated by permanent paraplegia and are, therefore, excluded from the results Of the remaining nineteen, five were treated functionally with one perfect result Twelve were treated by immobilisation in plaster, with three perfect results, all of which had residual deformity and one of which showed spontaneous fusion (Fig 4) Two were treated by immediate surgical fusion, one gained a perfect anatomical result, but neither was able to return to coal-face work because of pain This experience has been repeated in two other patients who have not yet been observed long enough to qualify for inclusion in the present series Although the total number of cases is small, it seems justifiable to conclude that since these are stable fractures, since orthodox treatment in plaster does not correct the deformity, and since a good anatomical result secured by grafting does not lead to a perfect result, functional treatment should be the method of choice Any conclusions based on such a small number of cases, however, must be regarded as tentative, and the final answer to this problem must await the result of further experience

CONCLUSIONS

Certain types of dorso-lumbar fracture are stable and the deformity will not increase if there is reasonable protection in the early stages In some of these (*e g* , dorsal fractures and lateral wedge fractures) the deformity cannot be corrected in any case, whilst in others it will inevitably recur if it *is* corrected The final anatomical result can be assessed accurately at the outset and, if this is within limits known from experience to be compatible with perfect function, there is no case for immobilising damaged soft tissues in an extreme position for many months—a procedure which in itself is likely to produce disability

In unstable fractures, deformity may increase beyond functionally insignificant limits and may jeopardise the cord in so doing More rigid protection is then necessary, but the aim should be to produce spontaneous anterior fusion in the best anatomical position compatible with that objective, and this is hindered rather than assisted by extreme hyperextension maintained for long periods Sometimes it may be necessary to reinforce anterior by posterior fusion, but it is doubtful whether posterior fusion alone will ever stabilise a spine that lacks anterior support

SUMMARY

1 A series of 166 fractures and fracture-dislocations of the dorso-lumbar spine has been reviewed

2 A new method of classifying these injuries is suggested

3 A type of fracture with lateral wedging, previously unidentified, which has certain distinctive clinical and anatomical features is described

4 The factors responsible for redisplacement are discussed and it is considered that in most cases this is predictable from the outset

5 At the present time orthodox treatment is based on the assumption that a perfect anatomical result is indispensable to a perfect functional result Analysis of the results in the series now reported shows that there are no grounds for this assumption

6 Treatment is discussed in the light of the foregoing conclusions This is based on a division of cases into stable and unstable types, the recognition of which is of crucial importance

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ATLANTO-AXIAL FRACTURE-DISLOCATION

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A young adult Indian male had complained for two years of fleeting pain in many joints with more or less continuous pain in the cervical region but no limitation of movement. He had been treated for "rheumatism" by several doctors. In January 1947 manipulation of the neck was advised and carried out at another hospital under sodium pentothal anaesthesia. On recovering from the anaesthetic the patient complained of excruciating pain in the midline of the neck beneath the occiput, which was quite different from the pain he had suffered before the manipulation. The head was fixed in a position of flexion with rotation to the left and there was a tingling sensation over the ulnar aspects of the forearms and hands, the medial aspects of the thighs, and the abdomen. He was kept in bed. Five days later he left the hospital, consulted this writer, and was admitted to the Department of Surgery of the University Witwatersrand, Johannesburg.

It was observed that he walked cautiously and deliberately. The head was held in acute flexion with slight rotation to the left. There was spasm of the cervical muscles, especially the paravertebral group, and movement was very limited and painful. Neurological examination revealed no objective signs though he complained of paraesthesia in both forearms and hands. Radiographs showed forward dislocation of the atlas on the axis with a fracture of the odontoid process. The atlas was tilted 60 degrees, the posterior ramus lay on the antero-superior surface of the body of the axis and there was lateral displacement to the full width of the atlas. The odontoid process of the axis was fractured at its base and displaced forwards and downwards with the atlas (Figs. 1, 4, 5).

The displacement was reduced on January 27, 1947, under intratracheal anaesthesia. A skull calliper was applied, the patient being placed on the operating table in such a way that the neck was supported on a wooden board, six inches wide, projecting from the end of the table. The cervical spine was extended and a Bohler screw-traction apparatus (of the type designed for fractures of the lower limb) so placed that the patient's shoulders rested against the upright bars of the frame, the cord from the calliper being attached to the hook of the wing screw (Fig. 6). The dislocation was reduced very gradually by tightening the winged screw and manipulating the frame in the desired position of traction. This manoeuvre lasted one and a half hours, during which time four radiographs were taken to check progress of the reduction (Fig. 2). When a satisfactory position had been secured a plaster jacket was applied. The skull calliper was left in position and weight-traction was continued for four weeks. Subsequently the calliper was removed and a new plaster applied. At this time there were no neurological symptoms and the patient was able to walk without discomfort.

Because of the notorious instability of this type of dislocation, cervico-occipital fusion was performed sixteen weeks later. A window was cut in the back of the plaster, and the base of the occiput and upper four cervical vertebrae were exposed through a midline incision. A gutter was made in the occipital bone by removing a strip of the external table, and the spinous processes of the second, third and fourth cervical vertebrae were split to receive a bone graft cut from the iliac crest. The graft was held in position by sutures of tantalum wire.

Three months later, radiographs showed that although there had been some recurrence of forward tilting of the atlas the position was acceptable and there was satisfactory consolidation of the graft. The plaster was discarded and a wool collar of Schanz type was worn for a further six weeks. At this time the head could be moved through about half the normal range and there was no pain on movement. Eighteen months later the patient reported

FIG 1

Fracture-dislocation of the atlanto-axial joint occurring after manipulation for rheumatism" of the neck The odontoid process is fractured and displaced forwards with the atlas (see also Figs 4–5)

FIG 2

FIG 3

Reduction was effected by screw-traction combined with hyperextension (Fig 2) Cervico occipital fusion was then performed with a bone graft and the condition fourteen weeks after operation is shown in Fig 3 The graft is well consolidated

that he had no symptoms and neurological examination showed no abnormal findings Flexion movement was limited by approximately 15 per cent, extension by 30 per cent, and rotation by 50 per cent Radiographs showed sound consolidation of the graft from the occiput to the third cervical vertebra

DISCUSSION

The classical account of "rotatory dislocations of the atlas" by Corner (1907) included a review of twenty cases, eighteen from the literature and two of his own This paper led to fuller understanding of the mechanism of these dislocations Corner emphasised the laxity of the atlanto-axial joint which allowed considerable movement without dislocation, and the fact that the muscles of the neck provided considerable protection against injury If these muscles are relaxed, the very lax atlanto-axial joint is susceptible to injury Lambotte (quoted by Mixter and Osgood 1910) reported the case of a young woman who sustained

FIG 4

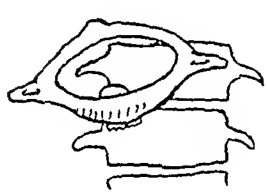

FIG 5
Tracings of the original displacement of the atlas and odontoid process

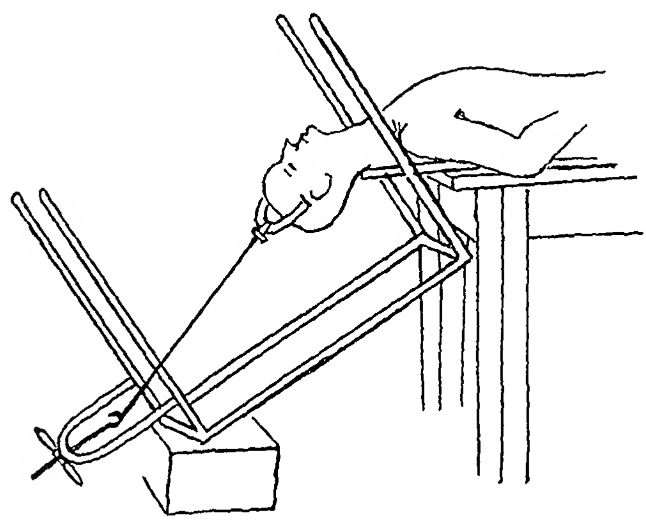

FIG 6
Reduction by screw-traction was secured by means of the Bohler limb-traction frame

complete dislocation of the atlas, with fracture of the odontoid due to a sudden movement of the head while sewing Wilson (1907) described a case of atlanto-axial injury in which it was believed that the displacement was caused by an osteopath who manipulated the patient's neck in the erect position

Atlanto-axial dislocation may cause cervical cord injury and death, either immediately or after a delay of hours, days, months or even years Broca (1863) reported a case proved at autopsy, the patient was an old man who died of urinary disorder and during life had carried his head obliquely Bernstein (1903) reported a fracture-dislocation between the atlas and axis in which evidence of cord damage was delayed until the seventy-first day Paralysis began in the right upper and right lower limb and spread slowly to involve the limbs of the left side and the bladder, rectum and diaphragm, the patient died after one hundred and one days At autopsy there was evidence of unilateral forward displacement of the atlas with callus formation at the site of the fractured base of the odontoid process, compressing the cord Costes (1855) described a similar case The patient was progressing well until the ninth week when paralysis began, death occured in the eleventh week Gibson (1885) reported a patient with dislocation between the atlas and axis with fracture of the odontoid process and clinical features similar to those of the case reported in this paper The head was set

forward with the chin resting rigidly on the sternum, and there was a prominence at the back of the neck below the occiput There were no abnormal neurological signs The dislocation was reduced by steady traction One week later, against advice, the patient sat up and immediately fell back dead Autopsy showed separation between the axis and atlas with the cord tightly stretched and pulled against the anterior wall of the canal The odontoid process was broken off at its base and displaced forwards with the atlas Another case was described by Elliot and Sachs in 1912, their patient died from paralysis after thirty-two years, "a long earthly existence with a broken neck " Watson-Jones (1943) considered that dislocation alone was more serious than fracture-dislocation, " because if the odontoid process is intact the spinal cord is in danger of being crushed against it "

From these references it is evident that atlanto-axial fracture-dislocation is not necessarily fatal and may even occur without cord-symptoms Nevertheless, in view of the extreme degree of displacement in the case here reported it seems almost miraculous that the patient suffered only minimal and temporary cord-symptoms and that apart from some limitation of movement in the upper cervical spine he is now entirely free from disability

Treatment—Reduction of the displacement may be secured slowly by continuous weight traction with a skull calliper, or by a one-stage manoeuvre The latter method was preferred in this case Immobilisation may be maintained by plaster but there is danger of recurrence of the deformity Cone and Turner (1937) described both immediate and late re-displacements, causing delayed nerve-root or spinal-cord symptoms Re-displacement and death have been reported after prolonged immobilisation in plaster either suddenly, as for example when the patient sneezed, or gradually by increasing recurrence of deformity

This instability of the reduction of fracture-dislocations can be overcome by cervico-occipital fusion Several successful cases have been described (Cone and Turner 1937) In the case now reported a graft from the iliac crest was used and the difficulty of maintaining contact of the graft with the occiput was overcome by the use of wire sutures of tantalum wire

SUMMARY

1 A case of fracture-dislocation of the atlas on the axis is presented in which the neck had been manipulated under anaesthesia for " rheumatism "

2 Despite marked displacement there were no important neurological complications

3 One-stage reduction by traction was carried out very slowly and with radiographic control It is believed that this is less distressing to the patient, and safer, than gradual reduction by prolonged traction

4 Because of the instability of the atlanto-axial joint after reduction surgical fusion of the upper cervical spine to the occipital bone is advisable

5 In the case now reported recovery was complete

The author wishes to express his grateful appreciation to Mr P Keen and Mr R J Fleming for their help in treating this patient and to Miss P Bilborough for the photographs

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SURGICAL ASPECTS OF THE TREATMENT OF TRAUMATIC PARAPLEGIA

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In the treatment of vertebral injuries with spinal cord involvement the views expressed in recent years by surgeons, some of whom advocate exploratory laminectomy whereas others favour conservative treatment, are no less controversial than they were in the time of Astley Cooper and Charles Bell, one hundred and twenty-five years ago Even among those who advocate surgical intervention the best time for laminectomy is still a matter of some disagreement, and this applies both to early and late operations

In assessing the indications for surgical intervention it is essential first to make a clear distinction between traumatic paraplegia due to closed spinal injuries and paraplegia due to compound spinal injuries such as stab wounds and, particularly, gunshot and shell wounds Moreover, the term " early treatment " must be defined more clearly than has been done in the past It has been interpreted differently by various authors Some, when they refer to " early laminectomy," mean exploration within forty-eight hours of injury, whereas others believe that operation after one to two weeks is still " early " A distinction should be made between surgical intervention at the most acute stage, within the first three days, and operation during the next two to three weeks Surgical intervention within the first three days may be termed " immediate operative treatment " as opposed to " early operative treatment " when the most acute stage has passed

IMMEDIATE OPERATIVE TREATMENT

Open spinal injuries—In open or compound spinal injuries, regardless as to whether or not they have caused complete or incomplete transverse spinal syndromes, immediate operative treatment is indicated as soon as general shock has been overcome, provided only that there is no associated injury to the lungs or other internal organs It should usually consist only of debridement Haematomata and foreign bodies such as bullets, pieces of cloth and bone splinters should be removed whenever possible The removal of such foreign bodies is indeed vital if there is leakage of cerebrospinal fluid Dural tears should be closed and penicillin and streptomycin applied locally If the dura is found to be intact it should not be opened unless there is absolutely clear evidence of a localised subdural haematoma if there is such a haematoma and if, as in the case of cauda equina lesions, it involves the anterior and posterior roots, these should be disentangled Such procedure was adopted during the recent war by most British and American neurosurgeons and, as a rule, it proved satisfactory

Closed spinal injuries with complete paraplegia—In closed spinal injuries due to fractures or fracture-dislocations this writer is in complete agreement with those who advocate conservative treatment and are strongly opposed to laminectomy as an immediate measure This applies to injuries with complete transverse spinal syndromes at any level, including cauda equina lesions It may be emphasised that at this stage the Queckenstedt test is of no diagnostic value in differentiating subarachnoid block caused by oedema of the injured spinal cord or pressure from the dislocated bone Moreover, in complete transverse lesions in which flaccid paraplegia remains unchanged for forty-eight hours there has usually proved to be either complete crushing and destruction of the cord or at least most severe damage which is irreparable

Importance of instituting rehabilitation immediately—These are the cases in which all efforts should be concentrated on rehabilitation from the very beginning The main points which have to be considered even in the immediate and early stages are the prevention of pressure sores, the control of urinary infections, the prevention of contractures of paralysed limbs

due to faulty position, such as keeping the legs constantly adducted, the hips and knees flexed, and the feet and toes in plantar flexion, and the development of the muscles of the trunk and upper limbs on which the patient will have to rely Everything should be done in these early stages to encourage development of readjustment forces in mind and body to compensate for loss of function in the paralysed parts of the body by increasing the action of the normal parts Details of the management of patients with traumatic paraplegia have been published elsewhere (Sandifer and Guttmann 1944, Guttmann 1945, 1946, 1947 and 1949)

Dangers of plaster casts and plaster beds—The application of plaster casts is contra-indicated because it leads almost invariably to the development of deep pressure sores This does not mean that the spine should be ignored completely, as was advocated by Magnus in Germany From the point of view of rehabilitation it is advisable to bring a badly displaced spine into the best possible position but this can usually be maintained by pillows or blankets without the application of plaster Plaster beds should be allowed only for transport and be discarded at the earliest possible date At the beginning of the recent war, plaster beds were recommended for the prevention and healing of pressure sores in patients with traumatic paraplegia, the idea being that pressure was then distributed more evenly This concept did not prove to be correct, the volume of the paralysed parts does not remain constant because there are changes in the degree of vasodilatation from interruption of the spinal vasomotor centres In fact, in those patients with paraplegia who lay in plaster beds for months—even when these beds had been constructed by experts—not only did this method of nursing prove to be no better in the prevention and treatment of pressure sores but it actually promoted the development of sores of the most frightful type In addition, this type of fixation may cause profound contracture of joints, distortion of the pelvis, and atrophy of the back muscles in normal parts of the body which are so vital for physical readjustment and particularly for the later maintenance of the upright position Moreover, stagnation in the renal system caused by prolonged recumbency and immobilisation may have devastating effects on the bladder and kidneys It has often taken months and even years of hard work to remedy, or at least to diminish, the damage caused by this form of fixation The conclusion drawn by the author from his own experience during and after the recent war is that the use of plaster beds, except for the purpose of transport, is contrary to the fundamentals of the rehabilitation of patients with traumatic paraplegia

Closed spinal injuries with incomplete paraplegia—In closed spinal injuries with incomplete cord or cauda equina lesions this writer also favours conservative treatment in the period immediately after injury, as a rule, operative intervention can be postponed safely There are, however, extremely rare instances of rapidly increasing epidural haematoma in which operative intervention is indicated at this early stage An excellent result thus obtained was described by McLean (1935) in a case of a fracture-dislocation of the eleventh dorsal vertebra Twelve hours after injury the sixteen-year-old patient showed only marked tenderness in the eleventh and twelfth dermatomes with analgesia in the distribution of the first and second lumbar nerves Sensibility in the saddle area was normal, as were the lower limb tendon reflexes The symptoms gradually increased and thirty hours after the accident there was almost complete paraplegia with absent reflexes and sensory loss which was more marked in the lumbar regions than in the sacral regions At operation, forty-eight hours after injury, dislocation of the vertebra was confirmed and partly corrected, and an epidural haematoma that was compressing the cord was evacuated A posterior plaster shell was moulded to the patient before he was moved from the table The clinical signs receded with a period of nine weeks At the thirty-eighth week there was a residual, incomplete Brown-Sequard syndrome

EARLY OPERATIVE TREATMENT

Open spinal injuries—In compound spinal injuries, particularly those due to gunshot and shell wounds, the main purpose of early operative intervention is the removal of foreign

bodies, especially when there is leakage of cerebrospinal fluid with X-ray evidence of a foreign body within or in the neighbourhood of the spinal canal, and bacteriological evidence of infection of the cerebrospinal fluid In such a case, removal of the foreign body is vital A soldier was admitted to this Spinal Centre from the battle-front in Germany on December 11, 1944, fourteen days after being hit in the back by fragments of an 88 mm shell which burst near him He had a complete transverse lesion at Th 11, with flaccid paraplegia There was a wound measuring 4 centimetres by 2 centimetres to the left side of the tenth thoracic vertebra which was discharging cerebrospinal fluid Bacteriological examination showed infection with Clostridia Welchii, B haemolytic streptococcus and B coliform bacilli Radiographs showed a large metallic foreign body in the region of the spinal canal at the level of Th 11 which was fractured On December 16, I removed a metallic foreign body measuring 4 centimetres by 1 5 centimetres No attempt was made to close the dura Post-operative treatment consisted of daily dressings with local penicillin The wound healed gradually, and the patient, although still paralysed, is now very fit and is gainfully employed as a commercial artist

Closed spinal injuries—In closed spinal injuries the indications for laminectomy during the early stages are

1) Incomplete lesions showing progression of the neurological signs In the writer's opinion, the presence of bone protruding into the spinal canal alone is no indication for surgical intervention in the early stages

2) Permanent manometric block without evidence of fracture or fracture-dislocation of the spine In such cases, which are very rare, laminectomy is justified in the early stages irrespective of whether the transverse spinal syndrome is complete or incomplete

3) Severe and constant irritation of spinal roots caused by displacement of bone fragments or prolapse of intravertebral discs This, however, is very rare in the early stages Elsberg (1940), for instance, in twenty years saw only one case of incomplete spinal lesion with root pain sufficiently severe to indicate early surgical interference In my own series of 370 patients with traumatic paraplegia treated during and after the recent war at Stoke Mandeville I have seen not a single case in which such surgical intervention was justified

LATE OPERATIVE TREATMENT

Laminectomy in the late stages of traumatic paraplegia has been carried out to serve three main purposes *a*) restoration of neural function, *b*) treatment of intractable pain, *c*) treatment of violent flexor or extensor spasms

Restoration of neural function—As a general rule " late laminectomy " does not serve any useful therapeutic purpose in complete transverse lesions at any level On the contrary, by weakening the stability of the spine and particularly the strength of those muscle groups of the back which are so essential for the upright position, it only delays the rehabilitation of the paraplegic patient to a useful social and industrial wheel-chair life Moreover, the post-operative shock has a most harmful effect during the first few days on the peripheral vasomotor control in the paralysed parts, thus causing lowered tissue resistance to pressure and greatly increasing the danger of pressure sores This conception is at variance with the opinion, generally held, that exploratory laminectomy is harmless

No single patient admitted to the Spinal Injuries Centre at Stoke Mandeville with a complete transverse lesion, due either to closed or open spinal injury, had gained any recovery of neural function of the damaged spinal cord by exploratory laminectomy performed before admission T B Dick (1949) compiled statistics relating to twenty-seven patients subjected to laminectomy more than seven days after injury at the Spinal Injuries Centre, Winwick Twenty-two had complete lesions before operation and, although only two proved to be anatomically complete, no patient showed evidence of later recovery Five operations were performed on patients with incomplete lesions three showed doubtful improvement which probably, as the author states, was not attributable to the operation Our observations are

in accord with those of McCravey (1945) and Cutler (1945), and it may be noted that in December 1944 the American Surgeon-General directed that late laminectomies in this type of spinal injury should no longer be carried out because it was considered useless in the attempt to restore neural function

Furthermore, late laminectomy should not be carried out indiscriminately in incomplete transverse lesions This writer is opposed to the recent recommendation that exploration is indicated even in the presence of neurological improvement if there is radiographic evidence of laminal damage (Haynes 1946) There is no hurry whatsoever, and it is nearly always safe to wait at least until the progress of recovery has ceased

On the other hand, there is general agreement that laminectomy is indicated in incomplete transverse spinal syndromes when there is evidence of increasing neurological signs The underlying cause of such clinical progression may be callus formation, or localised chronic pachymeningitis or leptomeningitis (arachnoiditis chronica progressiva cystica adhesiva) Riddoch (1927) and other authors have described cases of post-traumatic chronic meningitis in which the post-operative results were satisfactory Foerster (1929), though mentioning the satisfactory result of operation in several of his own patients, emphasised that in most patients with chronic post-traumatic arachnoiditis improvement in the spinal symptoms after operation was not very impressive, and he assumed that post-traumatic thrombosis of the spinal cord vessels was often responsible for irreversible lesions of the cord There are also selected cases of osteomyelitis with local pachymeningitis in which exploration may be indicated In one of my own cases in this series, in a naval officer, there was an incomplete lesion at the mid-thoracic region and, at operation, a track was found running down to the vertebra associated with localised pachymeningitis and very marked increase of fibrous tissue which was removed from the dura The result of the operation was satisfactory in so far as there was relief from pain, and arrest of the increasing motor weakness, although the effect on the spasticity was insignificant

Treatment of intractable pain—Pain is most frequent in cauda equina and distal thoracic cord injuries and is mainly of the causalgic type It also occurred in patients in this series with complete or incomplete cervical lesions, who were admitted with serious contractures of the elbow and shoulder joints The pain may be general or it may be referred to definite parts of the limbs or trunk It is often agonising and the life of the patient becomes almost unbearable The treatment usually given to patients with such pain before admission to this Centre had often included long continued injections of morphine and other narcotics and, sometimes, sympathectomy or cordotomy

The approach of this writer to the problem of pain in paraplegia, based on dissatisfaction with his own previous operative results with posterior rhizotomy and cordotomy, has been quite different from the beginning The essential principle of treatment is to mobilise, and develop to the highest possible level, readjustment forces in the mind and body of the patient in order to master the various symptoms of his disability, including pain This is achieved by appropriate psychological measures, healing and prevention of septic conditions, treatment of anaemia caused by sepsis, frequent passive movements and all forms of active physiotherapy including recreations and, above all, pre-vocational training which has proved the best possible form of occupational therapy by which to counteract frustration The prescription of morphia and other heavy narcotics which obviously impedes the mobilisation and development of these adjustment forces was reduced to a minimum, and in due course was almost completely abandoned Some years ago Gowlland (1934), when writing of the treatment of paraplegic patients, stated " I suppose that there is more morphia, atropine and hyoscine used in the Home which I look after than in any other place of the same size in the country " He continued " One of the snags is that some of these poor fellows who really do suffer and whose pain has been relieved by morphia, are apt to become addicts " In striking contrast to this approach, which still prevails in many centres for the treatment of paraplegia, it can be

stated that the Spinal Centre at Stoke Mandeville Hospital is one of the medical institutions where the *least* amount of morphia and other heavy narcotics is used for the treatment of painful conditions In some cases pain has not been entirely eliminated, but this has in no way prevented successful rehabilitation Repeated paravertebral injections of novocain have sometimes been employed and in two patients, where pain was associated with severe abdominal spasm, intrathecal injections of alcohol were successful It may be concluded that radical surgical procedures such as sympathectomy, posterior rhizotomy, cordotomy, and posterior column tractotomy have very limited application in the treatment of pain in traumatic paraplegia Surprising as it may seem, the apparently intractable pain is best relieved by general rehabilitation and retraining of the patient

Treatment of violent flexor or extensor spasms—In the past, severe flexor or extensor spasms were considered to be one of the most devastating complications of spinal cord injury, preventing rehabilitation and making the life of the patient intolerable During the last five years much research has been undertaken by which to distinguish the various causes underlying the mechanism of this spasm, and great progress has been made in treatment It can now be concluded that if adequate care and appropriate preventative measures are instituted *at an early date* after injury, exaggerated reflex activity of the paralysed limbs never becomes so severe that ambulation and rehabilitation is prevented The spasticity can be kept in check either by conservative methods or by simple operations such as lengthening of the tendo Achillis and neurectomy of the obturator nerves Obturator neurectomy has proved to be an excellent method of restoring the sexual activities of the paraplegic patient by eliminating adductor spasm which is the main obstacle to intercourse In patients who were admitted at *later dates* after injury, with profound reflex spasm of the paralysed limbs and resulting contractures, and whose previous treatment had consisted mainly of the administration of morphine and other narcotics, intrathecal injection of alcohol as described by the writer in 1946, and confirmed recently by Freeman and Heimberger (1948), Shelden and Bors (1948) and Gingras (1948), has proved very successful indeed in transforming spastic paralysis into a flaccid type which, from the point of view of rehabilitation, is so much more manageable This method has superseded radical operations, such as posterior rhizotomy (Foerster 1929) and anterior rhizotomy (Munro 1945), which necessitate general anaesthesia, laminectomy, and all the other discomforts and dangers which inevitably are associated with major operations

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HINDQUARTER AMPUTATION

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Gordon-Taylor described interinnomino-abdominal or hindquarter amputation as "one of the most colossal mutilations practised on the human frame" In 1934, in collaboration with Wiles, he reviewed all cases reported in the literature and showed that the mortalit rate had been 60 per cent In 1939, he reported eleven personal cases Since that time th operation has been practised with increasing success The first reports in American literatur were in 1942 (Leighton) and 1943 (King and Steelquist) More recently twelve hindquarte amputations were reported by Beck and Bickel (1948) but curiously without any reference a all to the pioneer work of Gordon-Taylor whose personal series now totals thirty-three cases

The operation is one of great magnitude and should be undertaken only after carefu deliberation There are still many surgeons who doubt whether it is ever justified, thei doubts being based not only on the slende chances of survival of patients whose hind quarters are amputated for malignant disease but also on the assumption that existence after such amputation must of necessity be miserable It is the purpose of this paper, in recording five cases, to show that greater optimism may be justified and that the joys of life can still be indulged in despite th mutilation It has even been possible to fit these patients with artificial limbs and teach them to walk without crutches So far as is known this has not been recorded before *

Fig 1

Case 1 W L Ossifying chondroma of the ilium potentially malignant, reaching from the lower pole of the left kidney to the left hip joint It was increasing steadily in size and, after a period of observation hindquarter amputation was clearly inevitable

CASE REPORTS

Case 1 W L, aged 42 years—First attended 1938 with one year's history of swelling in the le iliac region extending to the hip joint and the loin steadily increasing in size Radiographs suggested an ossifying chondroma of the ilium (Fig 1) Biopsy supported the diagnosis of non malignant ossifyin chondroma After one year the tumour was un doubtedly larger and was reaching up to the lower pole of the left kidney In 1940 the patient had lost weight and did not look well There was still no evidence of secondaries in the chest or elsewh r After consultation with Sir Harry Platt, and exami a tion of biopsy specimens by Professor Baker, it was agreed that hindquarter amputation was justified This was done in June 1941 The operation wa complicated by a urinary fistula which healed six months later He is now alive and well and has no complaints He uses crutches and has adapted his life accordingly, and is unwilling to consider the fitting of an artificial limb

Case 2 F G, aged 26 years—First seen October 1945 when she gave a six months' history of a painful lump on the lateral aspect of the right thigh increasing rapidly in size Clinical examination showed a tumour of the right femur in the region of the greater trochanter Open biopsy proved that it was a spindle-cell sarcoma (Fig 2) Clinical and radiographic examination showed no evidence of secondary growths Hindquarter amputation was performed December 1945 There was some sloughing of the upper part of the flap and oedema of the perineum but convalescence was otherwise uneventful (Figs 5-7) More skin than usual had been left in the posterior flap in the hope that it might prove possible to fit ar artificial limb A limb was fitted six months later in 1946 The patient is still alive and well, and thre and a half years after amputation is walking happily without crutches (Fig 8)

* *This paper was submitted for publication October 16 1948 (See Editor's footnote at the end of the article) It was read to the Boston Orthopaedic Club January 1949*

Case 3 A B, aged 42 years—First attended in July 1947 Clinical examination showed Von Recklinghausen s neuro-fibromatosis Complained of a painful lump on the antero-lateral aspect of the left thigh During the previous two months the tumour had grown with increasing speed and begun to ulcerate Biopsy showed evidence of an undifferentiated spindle cell sarcoma (Fig 3) There was no clinical or radiographic evidence of secondary deposits After hindquarter amputation convalescence was uneventful but three months later the patient died from massive secondary growths in the lungs

FIG 2

Case 2 F G Spindle cell sarcoma—mass of tumour cells exhibiting pleomorphism main cell type spindle some giant and multinucliate forms on the left side pink-staining homogeneous mass of osteoid tissue

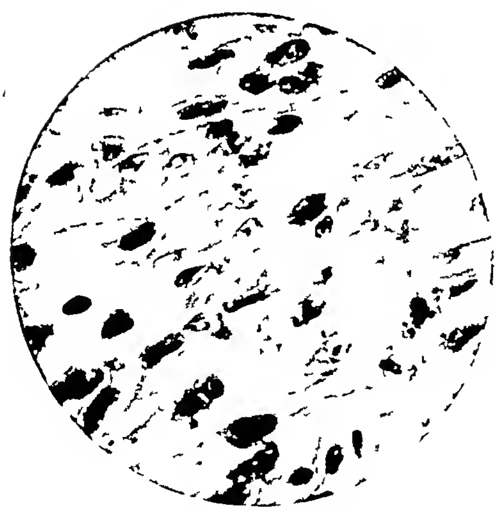

FIG 3

Case 3 A B Spindle cell sarcoma—closely packed mass of spindle shaped cells nuclei show alteration in size Numerous mitotic figures and pleomorphism was seen in other sections

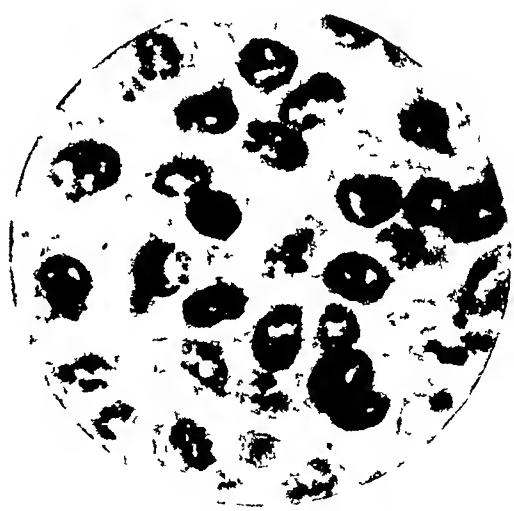

FIG 4

Case 4 G S Plasmocytoma—sheets of closely packed cells some oval some polygonal characteristic appearance of plasma cells, nuclei most eccentric with chromatin in darkly staining clumps

Case 4 G S, aged 34 years—First seen July 18 1947, when he gave a history of having slipped and strained his hip one week earlier Radiographs showed a tumour of the upper end of the femur involving the greater trochanter with fracture through the lesser trochanter which was avulsed the appearances suggested an osteoclastoma Investigation of the family history showed that one sister died at the age of twenty eight years from carcinoma of the breast and another sister died at the age of thirty-six years from carcinoma of the uterus After open biopsy it was reported that the tumour was a plasma-celled myeloma (plasmocytoma) (Fig 4) After consultation with other pathologists and Mr Osmond-Clarke,

Fig 5

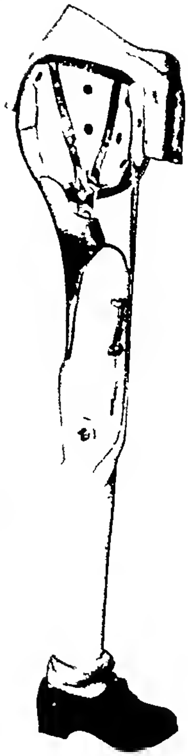

Fig 6

Case 2 Patient with hindquarter amputation who walked with an artificial limb without crutches Figure 6 shows the prosthesis the socket being made to a cast of the stump and fitted with an automatic hip lock

Fig 7

Case 2 Radiograph after hindquarter amputation showing that no more than a small fragment of ilium remains She walked with an artificial limb without crutches weight-bearing being from the costal margin

hindquarter amputation was performed on December 5, 1947 There was pyrexia for some days but recovery was otherwise uneventful and the patient is still alive and well He has been fitted with a prosthesis and is now walking and has discarded his crutches

Case 5 G W, aged 25 years—History of tuberculosis of the right hip joint with intermittent activity of disease since the age of five years Three years ago ischio-femoral arthrodesis was attempted but failed owing to involvement of the graft by disease The hip was unstable and there was four inches of true shortening Many sinuses were discharging, two of them profusely Radiographs showed extensive disease of both ilium and ischium with sequestration of the ischio-femoral graft The patient's general condition was poor there was a swinging temperature from 101 to 103 degrees, weight had gone down from eleven stone (154 pounds) to eight and a half stone (120 pounds), there had been many attacks of diarrhoea the Congo red test for amyloid disease was positive, radiographs of the chest showed an early active lesion in the right lung haemoglobin was 52 per cent After repeated blood transfusions the haemoglobin level rose to 82 per cent and under the control of streptomycin trans-iliac amputation was performed Four pints of blood were transfused during and immediately after the operation Nine months later the patient is alive and well

Technique of operation—The operative technique described by Gordon-Taylor has been followed faithfully except that in Case 2 the common iliac artery was tied instead of the external iliac artery This certainly made the operation easier but there was some sloughing in the anterior part of the flap It is difficult to attribute sloughing of the *anterior* flap to such arterial ligation but nevertheless the possibility of massive sloughing after ligation of the common iliac artery must be recognised The only other divergence from the technique originally described was that the ilium was cut through in a few seconds with hammer and chisel instead of with a Gigli saw In the five cases here reported the operative time was ninety minutes, eighty minutes, eighty-two minutes, seventy-five minutes and sixty-five minutes respectively It is interesting to compare these times with Gordon-Taylor's average time of sixty-five minutes and also with the four hours and forty minutes recorded by King and Steelquist for trans-iliac amputation The importance of blood transfusion throughout the operation, as in all such major procedures, calls for no emphasis Case 1 illustrates the danger of urinary fistula It is believed that the injury in that patient was inflicted on the bladder at the time that the symphysis pubis was being divided Special care must of course be taken to avoid damage to the ureters

THE FITTING OF ARTIFICIAL LIMBS TO HINDQUARTER AMPUTATIONS

In the second case reported in this series, more skin than usual was left in the posterior flap in the hope that some form of prosthesis might be fitted At that time, in 1946, the limb-fitting surgeons at Queen Mary's Hospital, Roehampton, thought that the fitting of an artificial limb was impracticable, but after consultation with Mr F H Powley of the Cambridge branch of Messrs Hanger & Co, Ltd, a limb was fitted to this young widow who was determined to persevere despite the almost insuperable difficulties

Mr Powley writes "The latest type of artificial limb that has been supplied for disarticulation at the hip joint was fitted in this case, there being just enough hindquarter left to which a socket could be fitted with the necessary seating A very careful cast was made of the pelvic stump on which the socket was made The limb was so fitted that there was minimal movement as the patient propelled and rotated her pelvis in taking a forward step The artificial limb attached to the socket was of light metal and had the latest improvements in mechanical detail and design, including an automatic hip lock This kept the thigh rigid with the socket while the patient was walking, but by pressing a small button over the outer side of the hip joint she could tilt the socket forward and sit quite normally On rising to walk, the hip lock engaged automatically Success in this case was due largely to the determination of the patient by which she succeeded in making the fullest possible use of the artificial limb"

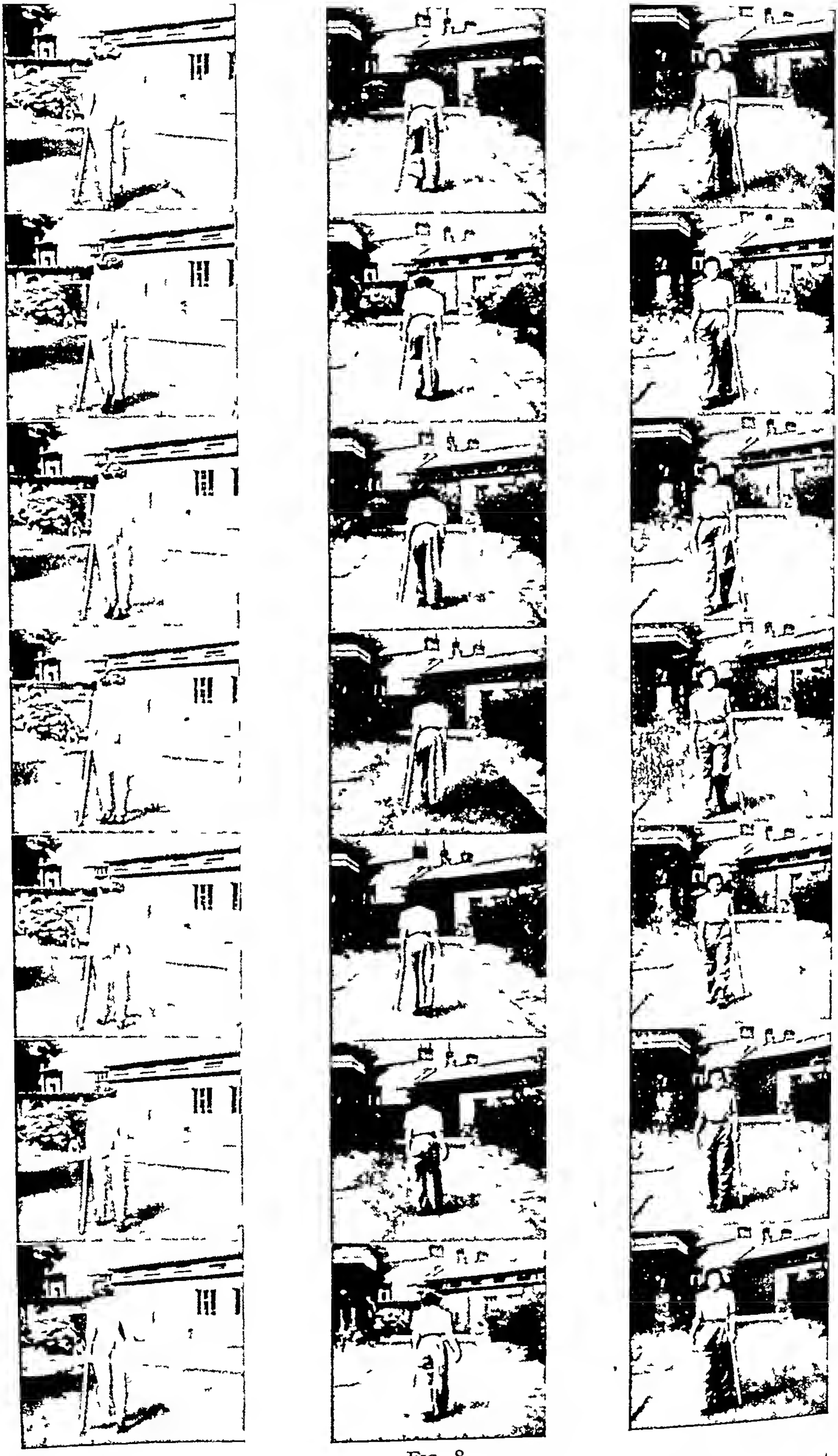

Fig 8

Case 2 Reproduction from a cine film showing patient walking with prosthesis, without crutches after hindquarter amputation

Three and a half years later this patient reports that she is well, still wearing her artificial limb and attending to all household duties She can walk half a mile without fatigue or pain (Fig 8) It may well be asked " On what is she walking? " We are aware of tibial-bearing in below-knee amputations and of ischial-bearing in below-knee and above-knee amputations We recognise that it is possible to bear weight after disarticulation through the hip joint But where is weight borne after hindquarter amputation? Radiographs show that in this particular case a small fragment of ilium remains lateral to the sacro-iliac joint but this does not provide a weight-bearing area (Fig 7) There can be little doubt that most of the weight is taken on the ribs and lower thorax As the patient takes weight on the artificial limb she inspires reflexly, holds her breath, and, being a thoracic-breather, thus fills the bucket of the limb

This determined young woman was the first patient to my knowledge to walk without crutches on an artificial limb after hindquarter amputation Others, in this small series of cases, have followed her example There seems no reason why every patient who suffers hindquarter amputation should not learn to walk without crutches

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Editor's Note—This paper was received for publication in October 1948 Since then other examples have been reported of patients who have been fitted with artificial limbs and have learned to walk without crutches after hindquarter amputation (Mitchell and Baird British Medical Journal November 1948, 2, 940 Wise, R A Journal of Bone and Joint Surgery, April 1949, 31 A, 426)

PULSATING ANGIO-ENDOTHELIOMA OF THE INNOMINATE BONE TREATED BY HINDQUARTER AMPUTATION

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The infrequency of pulsating angio-endothelioma of bone appears to merit the publication of an individual case in a short note rather than its inclusion in a list of thirty-three personal interinnomino-abdominal (hindquarter) amputations wherein the case might more readily be overlooked An appeal to the classical work of Ewing (1942) vouchsafes the information that the growth of endotheliomata tends to be slow but progressive, and thus they are comparatively benign More particularly, by comparison with the carcinomata and sarcomata which they may resemble histologically, the course of endotheliomata is relatively favourable When undisturbed by the knife the growth capacity of some of these tumours seems to be confined within certain limits which do not apply to carcinoma and sarcoma

It is said that endotheliomata spread by local infiltration, principally along existing channels such as lymph vessels and spaces, while extension to neighbouring lymph nodes, if it occurs at all, is late Such infiltration accounts for the difficulty of thorough extirpation and for the frequency of persistent local recurrence, each recurrence being apt to show an increasing capacity for growth This fact encourages the belief that the appropriate treatment is complete removal of the organ involved and not merely local extirpation of the tumour

Endothelioma of bone tends to replace pre-existing tissues with little or no increase in the size of the bone, but with perforations Three types of bone endothelioma were distinguished by Ewing 1) solitary, bulky telangiectatic angio-endothelioma, 2) multiple endothelioma of bone, 3) diffuse endothelioma of bone The solitary angio-endothelioma of bone, which is the type of tumour present in the patient now reported, affects adults and principally involves the long bones It grows steadily, perforates and invades the soft tissues and may, as a late feature, metastasize to the lungs, it may pulsate and produce a bruit Considerable variation in size may be observed, it is usually painful and sometimes causes pathological fracture The tumour consists of masses of large cuboidal cells in cords or pseudoalveoli enclosing freely circulating blood

Ewing also reminds us that a somewhat similar clinical and histological picture may be given by metastatic carcinoma of renal or adrenal origin, and that such a primary tumour must always be excluded in formulating the diagnosis

Other pulsatile osteolytic tumours may occur in bone, such as telangiectatic osteogenic sarcoma and giant-cell tumour Telangiectatic osteogenic sarcoma usually affects children and is characterised by exceedingly rapid growth and early pulmonary metastases Giant cell tumour of bone, when vascular and pulsatile, may cause great difficulty in differential diagnosis, its growth being slow like the angio-endothelioma, but usually the periosteum lays down a bony capsule which gives rise to characteristic radiographic appearances

Case Report—E B , female, 42 years of age, was admitted to hospital on April 15, 1949, with a history that five months earlier she had noticed pain in the right hip, rather posteriorly, which persisted for a month The pain was a dull ache, with an occasional sharper element, gradually spreading down the front of the thigh to the knee and from there to the front of the shin and the toes In the lower leg it tended to be a shooting pain, rather sharp like a knife It came on particularly in the morning and was eased by rest Lying on the right side caused discomfort in the limb which prevented her from getting to sleep, but did not awaken her when she was once asleep The pain made her limp

On examination—There was a mass in the right iliac fossa exhibiting marked expansile pulsation which could be obliterated by compression of the aorta A to-and-fro murmur

could be heard over the tumour The tumour presented on both surfaces of the iliac part of the os innominatum The diagnosis seemed to lie between a tumour of the innominate bone and an iliac aneurysm, with the odds heavily on a bone tumour The radiograph showed destruction of the wing of the ilium (Fig 1)

There was nothing abnormal in the cardiovascular, respiratory or central nervous systems The appetite had been indifferent but there was no other abnormality in the alimentary system The urinary system was normal and menstruation had ceased for the last eight months The patient was rather pale and thin, the skin, hair and nails were normal, thyroid not palpable, no superficial glands felt Pulse rate 76, regular, volume and tension normal blood pressure 160/85 heart sounds normal

FIG 1

Radiograph showing destruction of the ala of the right ilium by angio-endotheliomatous tumour The pyelogram shows a defect in the ureter at the pelvi-rectal junction on the right side

Blood count (*February* 1, 1949)—Haemoglobin 68 per cent , red blood corpuscles 3 85μ, colour index 0 88, P C V 34, white blood corpuscles 3,600 (polymorphonuclears 63 per cent , lymphocytes 33 per cent , monocytes 4 per cent) hypochromia, microcytosis, anisocytosis Erythrocyte sedimentation rate 20 mm in one hour

Faeces (*February* 8, 1949)—Occult blood—Benzidine, faintly positive, Guaiacum, negative

Radiographs of skull, ribs, sternum and vertebrae (*February* 8, 1949) — No evidence of myelomatosis in the ribs, skull, sternum or spine The opacity in the pelvis was presumed to be a solitary plasma cell tumour

Blood examination (*February* 11, 1949)—Total protein, 7 0 gms per 100 ml , albumen-globulin ratio, 2 3 1, fibrinogen, 0 38 gms per 100 ml

Red bone marrow examination (*February* 21, 1949)—Total nucleated cell count 67,000 c mm, myeloid/erythroid ratio 3 1, proerythroblast 2 per cent, early normoblast 4, intermediate normoblast 7, late normoblast 17, megalokaryocyte 0 2 per cent, myeloblast 1, premyelocyte 3, myelocyte 9, metamyelocyte 17, polymorphonuclear 33, lymphocyte 5 per cent, monocyte 1 per cent, plasma cell 0 3 per cent, no myeloma cells seen

Intravenous pyelography—Preliminary films—The tumour in the right ilium was considerably larger than on previous radiographic examination Both kidneys excreted the dye at five minutes The renal drainage system on the left side was normal On the right side there was a constant defect in the ureter at the pelvi-ureteric junction (Fig 1) The pelvis and calyces of this side were otherwise normal The nature of the defect was obscure and the lower part of the right ureter was displaced medially as if by the tumour An impression was also present on the right side of the bladder Retrograde pyelogram showed the same appearances as in the intravenous pyelogram The narrowing at the pelvi-ureteric junction could be explained by extrinsic pressure, and the deviation of the lower end of the ureter by the mass There did not appear to be any clear evidence of hypernephroma

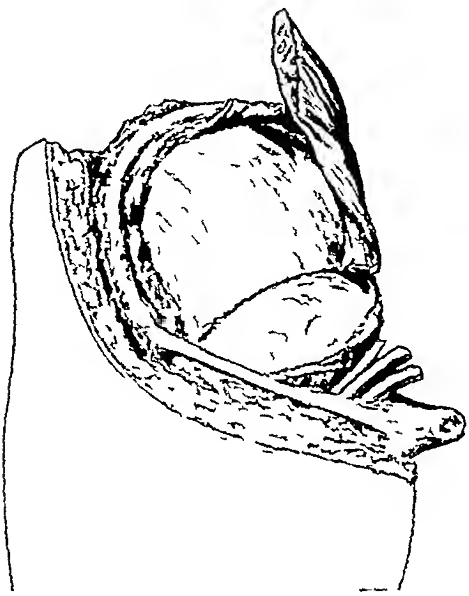

FIG 2

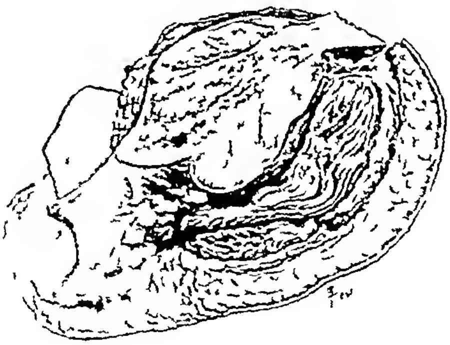

FIG 3

Specimen of angio-endothelioma of innominate bone showing relation to the iliac vessels and displacement of the ilio-psoas (Fig 2) and the same specimen on section (Fig 3)

Biopsy of tumour of right ilium (*March* 17, 1949)—An incision was made half an inch below the anterior part of the iliac crest and parallel to it There was considerable bleeding from the subcutaneous tissue and below the deep fascia, in the muscle the bleeding became so profuse that further approach from this direction was impossible The iliac crest was exposed and the muscle stripped off it for three-quarters of an inch Two pieces of bone were removed for biopsy they were macroscopically normal There was by this time so much bleeding from the bone as well as the other tissues that further progress was not practicable Accordingly, the bleeding was controlled by Oxycel gauze swabs and the wound closed, leaving two of these inside The tumour could be felt as a hard mass beneath the muscle, but it was not exposed or incised Histological examination of the biopsy fragments showed normal bone tissue, no tumour tissue being present

Radiograph of chest (*March* 17, 1949)—There was some cardiac enlargement and two opacities in the right lower thoracic zone The appearances indicated old calcified tuberculous foci No secondary deposits seen

Operation (*April* 20, 1949)—The usual preliminary operative approach to a hindquarter amputation was employed, which also gave adequate approach to the iliac vessels Owing to the extent of the tumour the whole innominate bone required removal, disarticulation at the sacro-iliac joint was necessary (Figs 2–3) During the operation and subsequent post-operative

period six pints of blood were transfused The patient made an uneventful recovery from the hindquarter amputation and left hospital, June 9, 1949, walking well on crutches

Histological Report (*April* 20, 1949)—Tumour 4 cms ×3 cms ×3 cms eroding the centre of the iliac bone The mass appeared to have a fibrous capsule, it had not invaded but had displaced the iliacus muscle above and the gluteus below On section, the tumour was composed of a firm outer rim three-quarters of an inch wide with a bony vascular centre

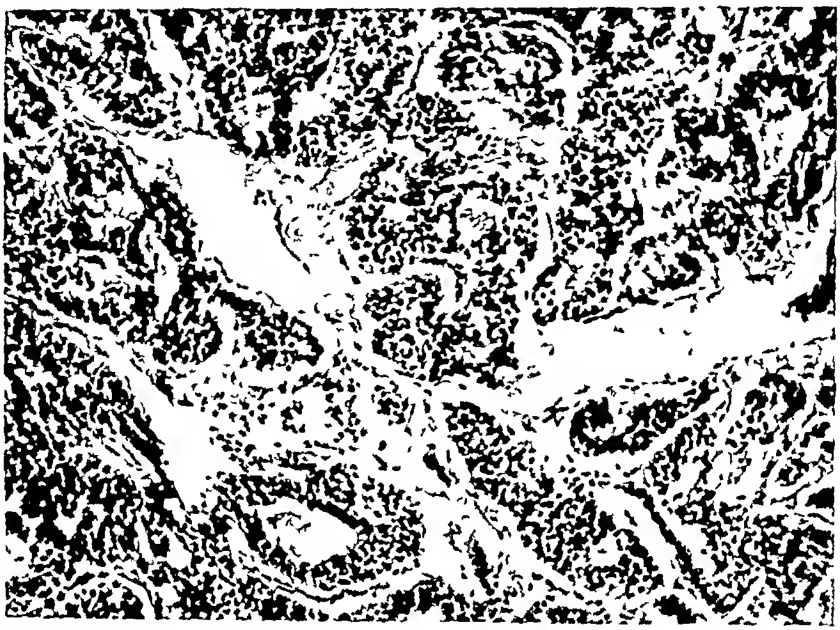

FIG 4

Microscopic section of haemangio endothelioma of the innominate bone

there were many spicules of bone in the tumour Section showed a cellular tumour replacing the bone the tumour showed numerous spaces containing blood, surrounded by several layers of endothelial cells The degree of differentiation indicated a moderate degree of malignancy (Fig 4)

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THE PAINFUL SHOULDER

Review of One Hundred Personal Cases with Remarks on the Pathology

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In considering the well-defined group of conditions in which there is limitation or alteration in the range of movement of the shoulder joint, pain on attempted movement and sometimes muscle wasting, with no radiographic evidence of abnormality, certain anatomical features must be recalled In the adult the capsule is fused with the overlying short rotator muscles, whereas in infants the capsule is separated from the deep muscles of the shoulder by areolar tissue, the tendons being short and the muscle fibres extending to within a few millimetres of their humeral attachment With increasing age the tendons become longer and in old age the supraspinatus tendon may extend as far proximally as the suprascapular notch The degree of adhesion of the tendons to the capsule increases with age, and in older subjects the fusion is complete The changes are more marked in the upper part of the capsule so that in adult life the entire breadth of the supraspinatus tendon, and the upper parts of the infraspinatus and subscapularis tendons, are intimately fused with the shoulder capsule

The frequency with which rupture of the supraspinatus tendon is found at post-mortem examination was emphasized by Codman (1931) and Codman and Akerson (1931) Grant and Smith (1948) demonstrated that degenerative changes in the capsule, especially in its upper part, increased in arithmetical progression as age advanced In ninety-five dissecting room specimens they found degenerative changes causing complete or incomplete rupture of the capsule in no case of a subject aged 17 to 40 years, in 25 per cent of subjects aged 40 to 56 years, in 39 per cent of subjects aged 56 to 76 years, and in 50 per cent of subjects aged 76 to 86 years It must also be recognised that falls on the shoulder are more likely to cause injury to the upper part of the capsule than to its anterior or posterior aspect For these three reasons—fusion of the supraspinatus with the capsule, increasing degeneration of this fused part as years advance, and liability to direct injury from falls—it is evident that most cases of "painful shoulder" are due to pathological changes in the upper part of the capsule

In this review, a series of one hundred patients have been re-examined at intervals ranging from one to three years after cessation of treatment The series includes only patients in whom there was no radiographic evidence of abnormality, examples of calcareous deposit in the tendons round the joint have been excluded The average age was fifty-two years There were fifty-two men and forty-eight women The right shoulder was affected in fifty-seven and the left in forty-three patients There was a definite history of injury in 60 per cent Three clinical groups were differentiated 1) rupture of the supraspinatus 2) supraspinatus tendinitis, 3) capsulitis of the shoulder

Rupture of the supraspinatus—After a fall on the shoulder there was diffuse pain over the shoulder and sometimes pain referred to the insertion of the deltoid muscle, with inability to elevate the limb, and inability to support it in the elevated position after it had been so placed, but with a normal range of passive movement In this group the disability was due to loss of the power of fixation of the humeral head to the glenoid by the spinatus; the deltoid was thereby put at such a disadvantage that although it was able to contract as could be felt by the examining hand, it was unable to sustain true shoulder movement In cases of recent rupture this loss of fixator function may be no more than a reflex phenomenon

* *Paper read at the Belfast meeting of the British Orthopaedic Association, October 21 1948*

induced by pain, because the uninjured infraspinatus, which is a larger and more important tensor and depressor of the humeral head than the supraspinatus, is also thrown out of action If this is accepted, it follows that it is impossible on clinical grounds to distinguish between complete and incomplete ruptures Clinical and operative experience has shown that this is true

In establishing the diagnosis there is a place for arthrography Radiographs are taken after the injection of 6 to 8 cubic centimetres of perabrodil (35 per cent solution) either into the shoulder joint as suggested by Oliver Axen (1941) or into the subdeltoid bursa as practised by the writer It can then be demonstrated in a few minutes whether or not there is communication between the bursa and the joint cavity It must be recognised, however, that although demonstration of a communication is strongly suggestive of complete supraspinatus tendon rupture it is not absolutely conclusive because in a small percentage of normal joints there is communication with the bursa (Axen 1941)

Supraspinatus tendinitis—In this series there were twenty-seven cases of supraspinatus tendinitis After direct injury, or sometimes spontaneously, a painful arc of movement during mid-elevation develops, with weakness of the limb and often with abnormal scapulo-humeral rhythm but without limitation of the range of movement Symptoms had been present, on the average, for five months The disability is often ascribed to impingement of an irritated or inflamed supraspinatus tendon against the under-surface of the acromion, but in two cases in which rupture of the supraspinatus tendon had been treated by suture with excision of the acromion there was still the typically persistent pain of supraspinatus tendinitis So much bone had been excised that acromial pressure could not have been the cause The work of Inman, Saunders and Abbott (1944) may throw light on this problem In myographic studies of the shoulder joint they noted that the peak of contraction of the supraspinatus muscle occurred between 80 and 120 degrees elevation of the limb This muscle contracts most powerfully in that particular phase of elevation which, in the group under consideration, is associated with pain, and it is possible that active contraction of a supraspinatus tendon which is irritable from inflammation or rupture may in itself be sufficient to cause pain

Capsulitis—Sixty-one cases were classified as examples of capsulitis occurring spontaneously or after injury There was pain, limitation of scapulo-humeral movement, weakness and muscle wasting The term capsulitis is used because it is believed that the essential pathology is inflammation of the capsule from injury or irritating causes within the joint Neviaser (1945) explored ten shoulders in order to determine the underlying pathology and found that the capsule was thickened and adherent to the humeral head, when the joint was manipulated the capsule separated from the head of the humerus in the same way that an adhesive bandage may be torn from the skin, and microscopic section of the capsule showed inflammatory and reparative changes If this view is accepted it is clear that two stages of the pathological process may be recognised 1) an early stage of acute inflammation, with inflammatory exudation in and round the capsule and limitation of shoulder movement due to muscle spasm which relaxes under anaesthesia, 2) a later adhesive stage, after resolution of the inflammatory process, in which there are fibrous adhesions limiting movement even when the muscles are relaxed by anaesthesia This concept of the pathology is borne out clinically, and it is my routine practice to examine every " frozen shoulder " under anaesthesia in order to test the range of movement and put each case into its proper sub-group of irritative or adhesive capsulitis

TREATMENT AND RESULTS

Rupture of the supraspinatus tendon—Of the twelve patients in this group, five were treated conservatively and seven by operation *Conservative treatment* consisted in complete rest of the shoulder joint in an abduction splint until the patient was able to raise the limb actively This took an average period of five weeks When this stage was reached the splint was

discarded and gentle exercises were practised, at first in the supine position Three patie regained full painless movement in twelve weeks, in the other two patients three quart of the normal range of movement was restored All returned to full work *Operative treatm* was carried out in seven patients, complete rupture of the tendon being found in every ca The acromion process was excised and the tendon was repaired Two patients gained fu recovery of function, two regained almost full movement but with weakness and pain mid-elevation, and three were not improved at all The most successful results were secur by simple longitudinal closure of the hiatus without attempting to suture any part of tendon to the tuberosity

Supraspinatus tendinitis—Of the twenty-seven patients in this group, thirteen gai full recovery without any treatment at all, or after simple rest in an abduction splint five or six weeks *Operative treatment* was advised in fourteen patients and carried out eleven In each case the acromion process was first excised When the subdeltoid bur was opened it was found in eight patients that there was a localised L-shaped or longitudin tear of the upper part of the capsule, in two there was swelling and longitudinal splitting the upper surface of the supraspinatus tendon, and in one there was rupture of the articula surface of the tendon discovered only after longitudinal incision by which to explore th " lump " in it This group of cases illustrates the difficulty in differentiating clinically betwee simple tendinitis and actual rupture of the supraspinatus Of the nine patients with incomplete rupture of the tendon the most successful results were gained in those in whom it was possible to bring the margins together longitudinally without tension They recovered full painless movement within four months with no more than slight residual weakness when tested against resistance All patients in whom there was a more complete rupture, and an attempt was made to suture the tendon to the tuberosity, made an incomplete recovery or no recovery at all

Capsulitis—There were sixty-one patients with capsulitis All were examined under anaesthesia so that they could be differentiated into the sub-groups of irritative and adhesive capsulitis

Irritative capsulitis—Twenty patients belonged to this group and were first seen afte average period of seven weeks from the onset of symptoms Pain was severe and alm constant, and it was worse in bed Movement was entirely scapulo-thoracic and elevati was to 70 degrees only Under anaesthesia full movement at the scapulo-humeral joint w possible Treatment was primarily by rest in an abduction splint or sling, no evidence bein found that the splint had any advantage over the sling Indeed several patients treated in a splint had to discard it because the pain was increased Gentle exercises were encouraged at an early stage, the exercises first being practised with the patient supine, they were encouraged by heat in its various forms On the average, full function with a normal range of painless movement was restored within three and a half months, although three patients developed adhesive capsulitis and needed manipulations before recovery was complete

Adhesive capsulitis—There were forty-one patients in this group who first attended for treatment after an average period of eight months Pain was less severe, and it was felt only after attempted movement of the shoulder which was mainly scapulo-thoraci The range of movement was not altered under anaesthesia When movement was forced adhesions were felt and heard to tear In this group the primary treatment was b manipulation under anaesthesia Since lateral rotation of the humerus is necessary for f abduction, this movement should be carried out first, in most cases this alone was suffici to free the shoulder After manipulation the limb was supported in an abduction splint two weeks and active exercises were practised from the beginning There was full recov within a period ranging from two weeks to four months In five cases three manipulatio were necessary, in the other thirty-six cases one manipulation was sufficient In the follow of this group, crepitus was found constantly during passive movements of the shoulder jo but the patient was usually unaware of it and the significance of such crepitation is uncerta

SUMMARY

1 In a series of one hundred personal cases of "painful shoulder" rupture of the musculo-tendinous cuff was proved by operation in eighteen cases and was presumed in eight further cases, namely, in about one quarter of the series

2 Of the eighteen cases treated by operation through the transacromial approach, perfect results were obtained only in four The other results were unsatisfactory In five, movement was good but there was pain or weakness of the limb In nine the condition was unaltered or made worse

3 Conservative treatment of traumatic lesions of the supraspinatus tendon is therefore advocated The advisability of rest of the shoulder joint in an abduction splint for five or six weeks is stressed Operative exposure, through a transacromial approach, is recommended only when conservative measures have failed

4 When there is rupture of the cuff there is evidence that simple longitudinal suture of the gap after freshening of the margins is likely to give better results than attempts to suture the medial end of the rupture to the greater tuberosity Most ruptures have a longitudinal extension of the initial transverse tear, and direct suture of the medial edge of the gap to the greater tuberosity may lead to shortening of the tendon and interference with its function

5 Ruptures of the supraspinatus tendon may cause no symptoms, lead to complete loss of function, or cause a painful arc of movement during mid-elevation The clinical state depends upon whether or not the condition of the ruptured tendon is causing pain, and whether the other short rotator muscles of the shoulder can compensate in tensor and fixator actions for the loss of action of the supraspinatus

6 Capsulitis is a convenient term by which to describe inflammatory lesions of the capsule and bursae around the shoulder joint The initial stage of irritative capsulitis may develop to the later stage of adhesive capsulitis Differentiation is important because treatment in the first stage is by rest, and in the second by manipulation and exercise

7 The subdeltoid bursa is the "peritoneum" of the spinatus tendons, like the peritoneum it shares the pathology of the organs it protects and is itself seldom the site of primary pathological processes

8 The management of the "frozen shoulder," whether loss of movement is protective or adhesive, calls for time and patience but the ultimate outlook is good

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THE PAINFUL SHOULDER

Significance of Radiographic Changes in the Upper End of the Humerus

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Radiographic changes in the upper end of the humerus at the site of attachment of th musculo-tendinous cuff have been described by Codman (1934) and Lindblom and Palm (1939) The literature is concerned mainly, however, with bone changes detected aft complete tears of the cuff whereas the intention of this paper is to emphasize the importan of the early bone changes that may occur *before there is clinical evidence of rupture of t tendons* These studies show clear evidence of pathological degeneration in and around th shoulder joint, involving bone and soft tissue, which has an important bearing on the diagno and prognosis

The early stage of this degeneration can exist without symptoms, but injury to a joint so affected readily gives rise to the various types of painful shoulder The term " degenerative lesion " is used (in cases in which there is no clinical evidence of actual rupture of the musculo-tendinous cuff) because the radiographic changes to be demonstrated are known to be associated with degeneration in the overlying tissues and there is no evidence of an inflammatory process such as might be indicated by the term " tendinitis "

Pathology and radiographic features—The characteristic pathological features are well illustrated by reference to an actual case (Figs 1–6) The subject was a male aged thirty six years who died from head injuries Relatives stated that at no time had he complained of injury or of symptoms referred to the shoulder Post-mortem examination showed evidence of an old tear of the subscapularis muscle (Fig 1) On the deep aspect of the tendon there was an area, about 1×1.5 centimetres, which had lost its normal sheen and had a roughened surface (Fig 2) The tendon was bound down to the anatomical neck by adhesions which made reflection difficult, and the underlying part of the head of the humerus showed pitting and erosion of cartilage Radiographs of the specimen showed a well-defined area of cyst cavitation (Fig 4) The affected area of bone and tendon was sectioned and the appearance of the cyst is illustrated in Figure 5 The cyst was multilocular and lined by fibrous tissue, and the adjacent area of bone and soft tissue had an appearance of homogeneous degeneration A radiograph of this section suggested that there was communication between the cyst and the anatomical neck at the site of attachment of the supraspinatus (Fig 6)

Examination of the left shoulder showed a similar early degenerative process affecting the deep surfaces of both supraspinatus and subscapularis (Fig 3) It is interesting to note that, as in the right shoulder, the changes were more advanced in the subscapularis than in the supraspinatus, though they had not progressed to the stage of tendon rupture There was adhesion formation, pitting and erosion of articular cartilage, and radiographic evidence of cystic cavitation

The association of complete tears, incomplete tears, early degeneration, erosion of cartilage and cystic cavitation has been demonstrated in other post-mortem specimens, and there can be little doubt that a degenerative process involving bone and soft tissue is frequently found in the middle and later decades of life Occupational trauma is undoubtedly a causative factor This degenerative process is of primary importance in the causation of complete and incomplete tears of the musculo-tendinous cuff

Radiographic appearances—The characteristic radiographic appearances, shown in Figures 7 and 8, are in marked contrast with those of a normal shoulder in which the clearly defined outline of the head of the humerus and the greater tuberosity and anatomical neck, and the trabeculation of cancellous bone, are constant features (Fig 9) The changes that indicate

* *Paper read at the Annual Meeting of the British Orthopaedic Association, Belfast, 1948*

Fig 1

Fig 2

Fig 3

Case 1 Male, aged thirty-six years Degenerative lesions of both shoulder joints with no symptoms during life Specimens removed after death The right shoulder shows an old tear of the supraspinatus tendon near its insertion (Fig 1) The deep surface of the capsule shows an area of roughening on the supraspinatus tendon (Fig 2) The left shoulder shows similar degenerative changes affecting the deep aspect of the subscapularis and supraspinatus (Fig 3)

Fig 4

Fig 5

Fig 6

Case 1 Radiograph of the dissected right shoulder shows an area of cystic cavitation (Fig 4) This is seen in macroscopic section in Figure 5 and a radiograph of the section is shown in Figure 6

a degenerative lesion at the attachment of the musculo-tendinous cuff are irregularity of the cortical bone of the greater tuberosity, erosion of bone of the articular surface of the head of the humerus, loss of the normal outline of the anatomical neck, cystic cavitation and areas of sclerosis

Clinical features—Immediately after injury it is impossible to differentiate clinically between a degenerative lesion and an incomplete tear of the musculo-tendinous cuff, and it is probable that in many cases both exist in the same patient Shoulders that have sustained injury and show radiographic evidence of a degenerative lesion give rise to a characteristic clinical syndrome with localised pain, limitation of abduction, pain on abduction, a painful arc of abduction, referred pain, nocturnal pain, abnormal scapulo-humeral rhythm and wasting of the spinati

Fig 7

Fig 8

Fig 9

The radiographic changes characteristic of a degenerative lesion are shown in Figures 7 and 8 They contrast markedly with the appearances in a normal shoulder shown in Figure 9

The painful arc of abduction has been described as peculiar to supraspinatus tendinitis but clinical observation suggests that it is found in a wide range of shoulder joint lesions and of injuries and osteoarthritis of the acromio-clavicular joint Pain referred to the insertion of the deltoid, or to the elbow and wrist joint, is a common finding, and in many patients there is no complaint of pain in the shoulder joint itself In the differential diagnosis it is often difficult to distinguish abnormalities of the acromio-clavicular joint but pain from this joint is usually referred along the trapezius muscle to the posterior aspect of the ear Nocturnal pain is a frequent symptom and is an indication that the muscles are reacting by spasm to an irritative process Abnormal scapulo-humeral rhythm is a further indication of spasm in the muscles guarding the shoulder joint Wasting of the spinati is rapid in onset and is important from the point of view of treatment Loss of power of these muscles not only causes impairment of external rotation but also of abduction movement, and when external rotation has once been lost and secondary changes have taken place in the anterior part of the capsule and subscapularis, it is difficult to gain full recovery

Review of clinical material—An investigation has been made of 145 shoulder joint injuries excluding major fractures and dislocations All patients reported with a history of injury and with varying degrees of pain and limitation of movement Patients diagnosed as having sustained " contusion " were those in whom the radiographic appearances were normal and there was no clinical evidence of specific soft tissue injury, patients diagnosed as having " degenerative lesion " were those in whom there were radiographic changes at the site of attachment of the musculo-tendinous cuff All age groups are included and the classification is shown in Table I

TABLE I

CLASSIFICATION OF 145 CASES OF SHOULDER PAIN AFTER INJURY, WITH INCIDENCE OF MAIN SYMPTOMS

Diagnosis	Total	Pain on abduction	Limitation of movement	Painful arc of movement	Localised pain	Reversed scapulo-humeral rhythm	Nocturnal pain	Referred pain
Degenerative lesions	26	26	22	7	22	3	3	8
Contusions	96	68	74	9	41	3	6	5
Supraspinatus tears	4	4	4		4			
Avulsion of bone	4	4	2		4		2	2
Fractures of tuberosity	3	3	2	1	3			
Calcification supraspinatus	2	1	1		1			
Muscle strain	3	3	2					
Osteoarthritis A C joint	2	1	2					
Injury acromio clavicular joint	2	1	2					
Subdeltoid bursitis	2	2	2	2				
Incomplete tear supraspinatus	1	1	1					

TABLE II

ANALYSIS OF ALL CASES OF PAINFUL SHOULDER AFTER INJURY IN PATIENTS OVER FIFTY YEARS OF AGE

	Radiographic findings	Number of Cases	Average duration of treatment
Group 1	Normal appearances	28	4 weeks
Group 2	Degenerative lesion	26	7 weeks
Group 3	Calcified deposit	1	3 weeks
Group 4	(Not radiographed)	15	3 weeks

Radiographs were available in 111 cases and they showed that there was a normal appearance in seventy, a degenerative lesion in twenty-six, acromio-clavicular arthritis in two, fracture of the greater tuberosity in three, calcification of the supraspinatus in two, and avulsion of bone from the greater tuberosity in four Patients in whom the radiographic appearances were normal and were classified as having sustained "contusions" had an average duration of hospital treatment of eighteen days, those with degenerative lesions had an average duration of hospital treatment of forty-nine days Four had complete tears of the supraspinatus, confirmed at operation Of the twenty-six patients with degenerative lesions, fourteen were women and twelve men, and the average age was fifty-two years This high age group is partly coincidental, because these lesions have been demonstrated

radiographically *in vivo*, and at post-mortem, in patients as young as thirty-six years. Analysis of all patients over the age of fifty years (Table II) indicates that radiographic evidence of degenerative changes was present in about half of them

At follow-up review, six to twelve months after injury, the significant finding was that every patient with radiographic evidence of degenerative changes reported residual disability. In contrast, apart from one patient who complained of some creaking, no case diagnosed as "simple contusion" showed any residual sign or symptom

Treatment—This paper is concerned primarily with diagnosis, but two points in treatment justify comment In the first place, in shoulders that are subject to early degenerative lesions any movement of the limb that initiates pain may aggravate the symptoms and prolong the disability To avoid this one of three courses may be adopted namely—rest in a sling for six weeks with the limb adducted, elevation and fixation by means of a head halter for six weeks, or excision of the acromion Treatment by simple rest in a sling is supplemented by supervised exercises with the arm adducted, and similarly halter treatment is controlled by supervised exercises in the abducted position A halter is certainly more effective than a sling, but it is difficult to persuade patients to persevere with this position for an effective period Rest in a sling with the limb adducted and internally rotated encourages atrophy of the external rotator muscles and may lead to secondary contracture with a risk of permanent limitation of movement *To avoid these* difficulties a series of cases with degenerative lesions has been treated by excision of the acromion but sufficient time has not yet elapsed to justify comment

FIG 10
Head halter with wrist strap

Secondly, after repair of a complete supraspinatus tear it is important to treat the patient with the limb in abduction The patient leaves the operating theatre with the arm abducted on a Middledorfs' triangle The fully abducted and externally rotated position of the arm, necessary for fixation in a head halter, is secured by the third or fourth day (Fig 10) When the head halter is fitted, the patient is allowed up, the position of abduction being retained for six weeks

SUMMARY

1 Degenerative lesions of the shoulder joint can often be demonstrated radiographically before there is actual rupture of the musculo-tendinous cuff

2 The characteristic pathological, clinical and radiographic features of degenerative lesions are described

3 All injuries of the shoulder joint, however trivial, occurring in patients over middle age, should be studied carefully by radiographic examination

4 In injuries of the shoulder joint the presence of a *degenerative* lesion prolongs the duration of symptoms, and the prognosis is less satisfactory than when there is no radiographic evidence of abnormality

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EARLY ASSESSMENT OF SUPRASPINATUS TEARS

Procaine Infiltration as a Guide to Treatment

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One of the difficulties in the management of tears of the musculo-tendinous cuff of the shoulder joint arises from the lack of clearly defined criteria on which to base the indications for operative or conservative treatment early in the course of the disability Clinical assessment of the extent of the tear is often unreliable and only after the lapse of time does evidence of persistent disability lead to the confident diagnosis of an extensive tear that requires suture On the other hand, over 50 per cent of patients with supraspinatus tears may make a satisfactory functional recovery without operation This paper is concerned solely with the presentation of a simple practical test by which an early decision may be made as to whether or not operative treatment is needed

A series of 109 cases, diagnosed clinically as supraspinatus tears, was studied with particular reference to the recovery of function obtained without operation and regardless of apparent initial severity The series included all patients attending the Orthopaedic Clinic of the Western Infirmary, Glasgow, over a period of three and a half years when conservative treatment was employed almost without exception There were seventy-eight men and thirty-one women, with ages varying from 29 to 72 years (70 per cent being in the fourth to the sixth decades) Sixty were manual workers There was a history of precipitating injury or sudden muscle strain in 103 of the 109 cases

Criteria for diagnosis—The diagnosis of supraspinatus tear was made clinically on the history of sudden pain in the shoulder joint, often referred to the deltoid origin and usually precipitated by a fall or sudden muscular effort, tenderness localised between the acromion process and the great tuberosity, painful arc of abduction movement, loss of voluntary abduction, greater range of passive than of active movement, and radiographic exclusion of fracture, joint lesion or calcified deposit Tears associated with fractures or dislocations were excluded Undoubtedly the diagnosis of an incomplete tear cannot be made with certainty on clinical grounds Cases placed in this group will often include minor contusions and abrasions of the subacromial bursa, contusions of the tendinous cuff and of the tuberosity, as well as true small tears of the tendon substance Nevertheless the cases in this clinical group, as noted in Table I, showed a uniformly good prognosis and presented no great problem in early treatment In patients with more acute and more gross symptoms there is less difficulty in reaching a confident diagnosis of shoulder cuff tear, but the prognosis is more uncertain and it is to these more severe lesions that attention is directed

Clinical assessment—In an endeavour to correlate the initial clinical picture with the ultimate prognosis, cases were graded arbitrarily on the findings recorded at first examination into one of three clinical groups—mild, moderate and severe "Mild" cases were judged to be those with a characteristically painful arc of movement and with tenderness but with a full range of abduction, "moderate" cases were those in which there was inability to initiate abduction of the arm from the side but ability to sustain the limb in the abducted position after it had been raised passively beyond 90 degrees, in "severe" cases there was both inability to initiate abduction and to sustain the limb in abduction after it had been raised passively

* *Paper read at the Annual Meeting of the British Orthopaedic Association Belfast* 1948

The patients were treated conservatively by the support of a sling and local heat (79 cases), rest in an abduction frame (18 cases), or repeated injection of local anaesthetic (12 cases) Active shoulder exercises were encouraged as soon as acute discomfort had settled No particular merit could be ascribed to any one form of treatment and the numbers are too few to justify detailed comparison

TABLE I

ANALYSIS OF FUNCTIONAL RECOVERY IN 109 PATIENTS TREATED CONSERVATIVELY

Clinical grading	Number of cases	Full recovery	Incomplete recovery	No recovery
Mild	53	46 (87%)	7 (13%)	—
Moderate	22	13 (59%)	7 (32%)	2 (9%)
Severe	34	18 (53%)	12 (35%)	4 (12%)

Results—Analysis of the recovery of function after conservative treatment in the three clinical groups is shown in Table I

In the group graded clinically as "mild" the prospect of recovery with conservative treatment is good—and mild cases can be segregated clinically with ease The real problem arises in attempting to determine the best treatment in more severe lesions in which clinical assessment alone is inadequate as a guide to prognosis and treatment All that it is possible to say is that of cases classed as "severe" about half recover completely without operation even if, at first, it appears that all power of abduction has been lost In the earlier stages, pain and muscle spasm are such that active abduction is always inhibited The tendency, therefore, has been to advise operation only if there is not return of abduction power after a period of conservative treatment The alternative policy of exploring all apparently severe lesions at the outset would lead to many unnecessary operations

ASSESSMENT WITH PROCAINE INFILTRATION

In a later series of twenty-seven patients, a local anaesthetic was injected into the painful area of the tendon in the hope that relief of shoulder pain and spasm might permit more accurate assessment of supraspinatus function This investigation was confined to patients who showed complete loss of the power of abduction Ten cubic centimetres of 1 per cent procaine was used After five minutes, the ability to initiate and sustain abduction was reassessed In a number of patients full active abduction was temporarily restored and these were recorded as showing positive procaine tests All patients, as in the first series, were observed throughout a period of conservative treatment

TABLE II

ANALYSIS OF FUNCTIONAL RECOVERY IN TWENTY-SEVEN PATIENTS TESTED INITIALLY WITH PROCAINE

Procaine test	Total cases	Full recovery	Full abduction with residual painful arc	Abduction less than full (to 100 degrees)	No abduction recovery
Positive	16	8	5	3	—
Negative	11	—	—	3	8

Positive Procaine Test—Pain and tenderness abolished, abduction restored temporarily
Negative Procaine Test—Pain and tenderness abolished abduction *not* restored

Results—Analysis of the subsequent clinical course is shown in Table II In six of the patients with negative procaine tests the shoulder cuff was explored later, all had tears involving the whole supraspinatus segment and in some the infraspinatus segment was also involved

CONCLUSIONS

The series is small but the findings appear to justify the continued use of procaine infiltration as an aid to initial assessment of shoulder cuff tears A positive procaine test indicates a fair prospect of satisfactory spontaneous recovery even in patients who show clinical evidence of an apparently severe lesion On the other hand, a negative procaine test is an indication that spontaneous recovery is unlikely and that operative repair is advisable

It is suggested that the early management of supraspinatus tears should be on the lines laid down in Table III

TABLE III

Extent of tear	Treatment
CLINICALLY MILD	CONSERVATIVE
CLINICALLY SEVERE but abduction temporarily restored by procaine infiltration	CONSERVATIVE in the first instance
CLINICALLY SEVERE and abduction not restored even temporarily by procaine infiltration	EARLY OPERATIVE REPAIR

SUMMARY

1 The end-results of conservative treatment of supraspinatus tears have been studied in a series of 109 patients graded on a clinical basis, and in a further series of twenty-seven patients assessed initially by procaine infiltration

2 In 87 per cent of patients with mild lesions, full function was regained in an average period of five and a half weeks In more than 50 per cent of patients with apparently severe lesions, there was full functional recovery in eleven to thirteen weeks

3 Clinical assessment, other than as mild or apparently severe, is unreliable in the early stages

4 Procaine infiltration of recent tears, by abolishing pain and spasm, allows more accurate assessment of supraspinatus function and gives a more clear indication as to the advisability of conservative or early operative treatment If such infiltration of the torn segment of tendon fails to restore voluntary abduction power, early operative repair is indicated

5 Six patients with negative procaine tests, in whom the shoulder cuff was subsequently explored, all showed extensive tears

The author wishes to thank Mr Roland Barnes for generous help and valued criticism

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SHOULDER PAIN

With Particular Reference to the "Frozen" Shoulder

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It is believed from investigation of patients with "frozen shoulder" that the syndrome can be correlated with certain other types of shoulder pain It is characterised by a well-known cycle of events 1) there is increasingly severe pain in the shoulder, spreading down the arm sometimes developing after injury, in a patient aged fifty to sixty years, 2) the pain persists and gleno-humeral movement decreases until only about twenty degrees remain, 3) the pain becomes less severe but stiffness persists, 4) the pain subsides and movement is slowly regained The cycle may take from six months to two years It is usually believed that the prognosis is excellent and that there is nearly always complete recovery (Codman 1934 Wilson 1943, Ferguson 1938, Lippmann 1944, Moseley 1945), but this has not been our experience In a small series of twenty-one patients who suffered from "frozen" shoulder more than three years ago only six regained normal function, nine have both weakness of the joint and persistent pain, and six complain either of weakness or loss of movement

It is often stated that the movements that are lost are external rotation and abduction but the fact is that there is approximately equal limitation of movement in all directions from the position in which the limb is rested If the limb is supported by the side of the trunk in a sling, abduction is limited, but if it is splinted in abduction the shoulder "freezes" in that position

Pathology—In four patients with "frozen" shoulder, parts of the bursa, supraspinatus tendon and biceps tendon were removed for histological examination and for comparison with similar specimens obtained at autopsy in subjects of the same age (Fig 1) The fact that in these cases there was no increase in the range of movement when the patient was deeply anaesthetised indicated that the stiffness was not due to spasm The subacromial bursa appeared thickened and oedematous and it showed increased vascularity, but there were no adhesions between its walls The tendinous cuff also showed increased vascularity and it seemed abnormally thick and closely applied to the head The cuff could be likened to a vascular, leathery hood with no obvious demarcation between the tendons Attempted movement demonstrated that there were tight inelastic tissues all round the joint The biceps tendon moved freely and was reddened only where it was in contact with the supraspinatus (contrast Lippmann, 1943), and excision of the tendon permitted no increase in the range of movement The joint itself was normal and there were no intra-articular adhesions *Microscopy* of the bursa and the tendon confirmed the naked-eye findings The bursa showed chronic inflammatory reaction with hyperaemia The supraspinatus tendon showed similar inflammatory changes spreading inwards from the periphery There was evidence of degeneration and focal necrosis with marked increase of vascularity (Fig 2)

DEGENERATIONS AND INFLAMMATION OF THE SUPRASPINATUS TENDON AND CAPSULE OF THE SHOULDER

Some authors have believed that the primary changes in "frozen" shoulder are in the subacromial bursa but it has been shown by Codman (1934) and other surgeons who have made special studies of the shoulder that these changes are merely secondary, and this is confirmed by our observations Simple bursitis nearly always clears up rapidly with rest and although chronic bursitis might cause persistent effusion and adhesions it is a very

* *Paper read at the Annual Meeting of the British Orthopaedic Association, October 1948*

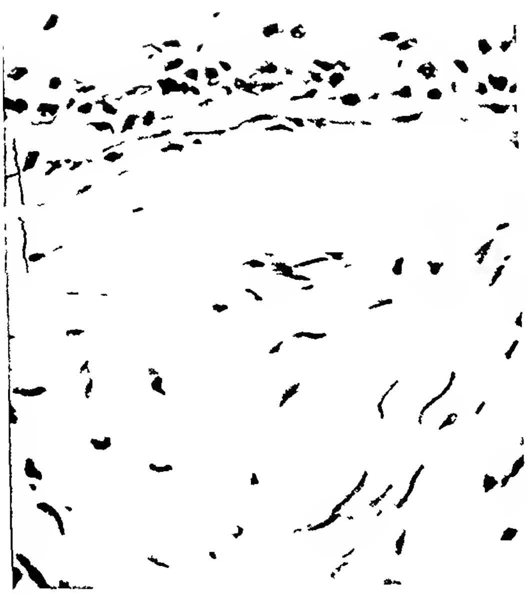


FIG 1

Section of peripheral part of supraspinatus tendon in a cadaver (age 55 years) showing poor staining of the collagen fibres and loss of the normal wavy appearance The picture is that of degeneration without inflammatory reaction (×90)

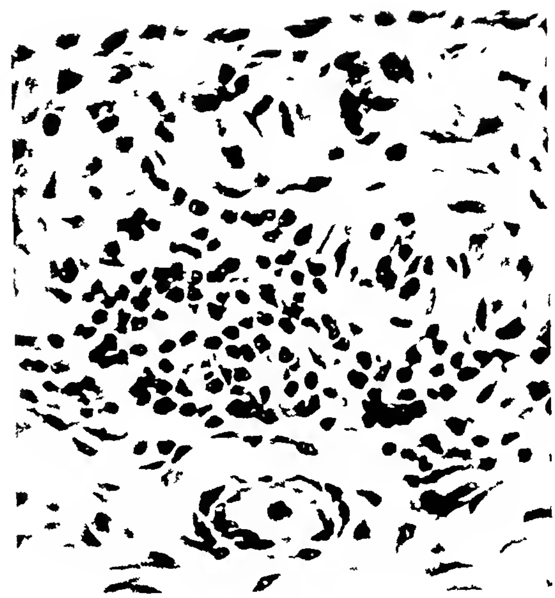


FIG 2

Section of peripheral part of supraspinatus tendon in a male patient with ' frozen ' shoulder (age 57 years) The collagen is degenerate several blood vessels with lymphocytes and histiocytes are seen, there is chronic inflammation (compare Fig 1)

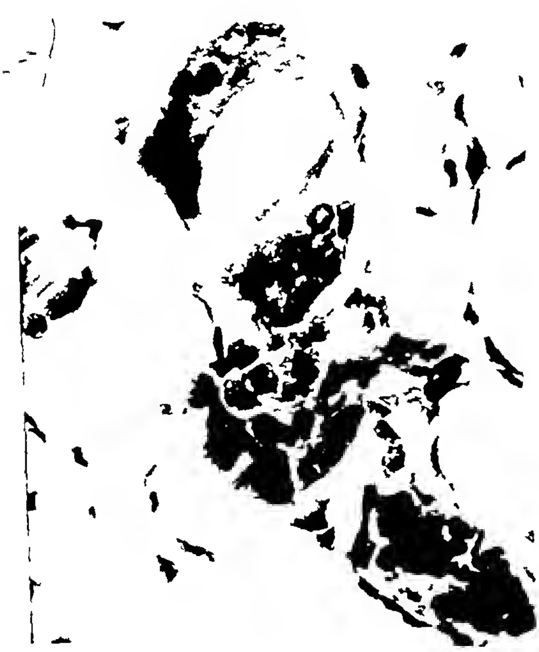


FIG 3

High power view of section of supraspinatus tendon from same patient as shown in Figure 2 (×400) One huge multinucleate cell surrounds necrotic areas of tendon some of which has dropped out of the section

FIG 4

Low power view of a section from a different part of the supraspinatus tendon in the same patient as shown in Figures 2 and 3 (haematoxylin and eosin ×80) showing the extraordinary degree of vascularity

uncommon lesion and no evidence of it was found in the cases of "frozen" shoulder that we explored at operation

Biceps tendinitis and peritendinitis have sometimes been regarded as the cause of "frozen" shoulder but the tendon did not show significant changes in any of the shoulders we explored and it seems clear that biceps tendinitis is not a primary factor The same is true of the joint itself It must be assumed, therefore, that the basic cause of "frozen" shoulder does not lie in the joint, the biceps tendon, or the sub-acromial bursa It is the fixator tendons and the capsule that are primarily affected The whole tendinous cuff has an abnormal appearance but it is the supraspinatus tendon, which shows evidence of a vascular reaction around areas of degeneration, that is essentially involved This is supported by certain observations 1) "Frozen" shoulder seldom occurs when the supraspinatus tendon is torn and retracted, the typical clinical picture of such a lesion is that of painless loss of function with full passive movement (Codman 1934, Wilson 1943, Ferguson 1938) It is the incomplete tear, which is characteristically painful, that may proceed to the "frozen" shoulder, whereas in the complete tear that has been sutured a longstanding painful shoulder may develop 2) Pathological changes occur in the supraspinatus tendon far more commonly than in the other tendons of the cuff This is not surprising because the supraspinatus tendon is the longest, and most exposed to injury from friction against the acromion process or the coraco-acromial ligament Rupture is more frequent in this than in other tendons and there is good evidence that a tendon seldom tears unless it is degenerated or has impairment of its blood supply (Wilson 1943, Lindblom 1939, Cronkite 1935, McMaster 1933) Similarly, calcified deposits, which probably represent areas of necrosis, occur most commonly in the supraspinatus tendon In autopsies of aged persons a high incidence of degenerations and tears of the supraspinatus has been recorded (Codman 1934, Wilson 1943, Wilson and Duff 1943, and Herman Wahren 1942) The fact that these lesions have often been symptomless is probably accounted for by the nature of the surrounding tendinous tissue which in old age may be incapable of a vascular reaction If, then, the supraspinatus is the site of the primary lesion in "frozen" shoulder it would be expected that the fundamental fault is degenerative But the tendon is not so degenerate that vascular response is impossible, or there would be no pain, and that is why the syndrome occurs at the age of fifty or sixty years rather than later

It is submitted that the "frozen" shoulder syndrome is caused by a chronic inflammatory reaction in the supraspinatus tendon due to atypical features in the processes of degeneration that occur constantly in this tendon with advancing age (Figs 3 and 4) The sequence of events is 1) the supraspinatus undergoes irregular and widespread degeneration with focal necrosis 2) the tendon reacts by inflammation as it would to a foreign body, 3) the inflammatory reaction is painful, spreads to the bursa, and causes inefficiency in the function of the supraspinatus, 4) the painful area is constantly injured by impact against the acromion process and the coraco-clavicular ligament, and the limb is therefore rested in the sling position, 5) the capsule and cuff, because of a nearby inflammatory process coupled with lack of use, become inelastic with consequent loss of movement in all directions from the sling position If necrotic areas in the tendon are absorbed, and the tendon is revascularised the inflammatory reaction is no longer invoked and a painless stiff shoulder develops which slowly regains its movement (Table I)

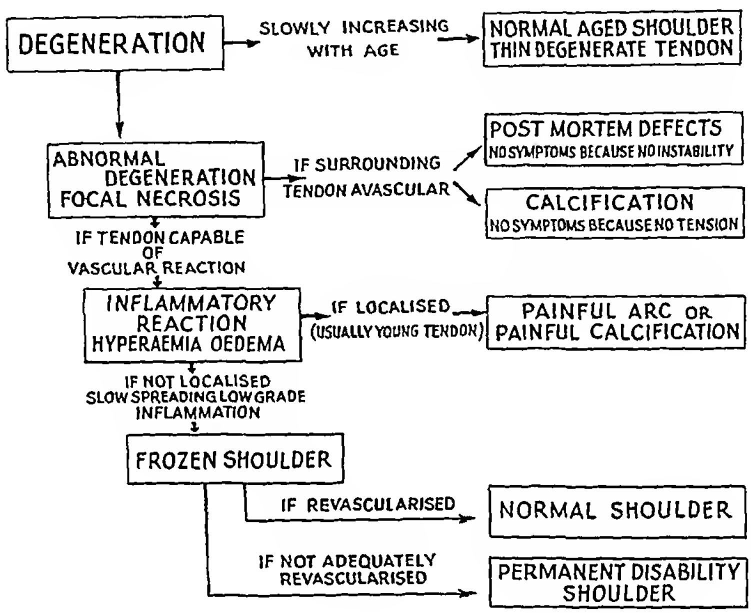
If the shoulder returns to normal, recurrence does not occur because the supraspinatus tendon has been revascularised, it may indeed have a better blood supply than before But if the vascular response has been inadequate, tendon defects, tears of varying size, and secondary biceps tendinitis may develop All stages between the weak but painless shoulder and the weak and painful shoulder may be seen

The cause of the degenerative changes is difficult to determine, but it is probably associated with impairment of blood supply due to injury of the tendon by impact against

the acromion process and coraco-acromial ligament, especially in patients with cardio-vascular disease, and at the climacteric, when abnormal and irregular degeneration may be caused by sudden changes in vascularity The "frozen" shoulder syndrome is more frequent when there is coincident cardio-vascular disease and, moreover, 60 to 65 per cent of cases are in women (Lippmann 1944, Codman 1934) The average age of onset is a few years younger in women than in men (Codman 1934)

TABLE I

RESULTS OF DEGENERATION AND INFLAMMATION IN THE SUPRASPINATUS TENDON



Treatment—The aims of treatment of "frozen" shoulder due to degenerations and inflammations of the supraspinatus tendon and shoulder cuff should be 1) to improve the blood supply, and 2) to preserve elasticity of the tissues Increase in the blood supply may be promoted by radiant heat and diathermy, and by local interruption of the sympathetic nerves, but in practice these measures appear to be of little more than theoretical value We have no experience of the hormone therapy that has been advocated (Walton, L H F Personal communication)

Preservation of elasticity without inflicting further injury is not easy Continuous traction which separates the tendon from its pressure points may be of value Another method is to abduct the shoulder widely, restricting movement to an arc above the right angle, which was advocated by Codman He rested the patient in bed and gradually pulled the limb into wide abduction Once the great tuberosity had slipped under the acromion, patients were immediately more comfortable, and they began gleno-humeral movement in this highly abducted position The chief difficulty is economic Patients are unwilling to undergo prolonged hospital treatment unless the pain is very intense and a cure is guaranteed As a rule it is necessary to accept the compromise of out-patient treatment with rest of the limb in a sling gentle pendulum exercises, and perhaps novocain injection All too frequently the sequel is a year or more of misery Manipulation, or exercises in the erect position, are contra-indicated in the painful phase, because they lead to further injury

BICEPS PERITENDINITIS

Primary biceps peritendinitis—The course of the long head of biceps through a narrow tunnel over a mobile joint renders it unusually liable to inflammatory changes at its surface and in the peritendon (Hitchcock and Bechtol 1948). Lippmann (1943, 1944) found evidence of biceps peritendinitis in all of thirty-two "frozen" shoulders on which he operated. He claimed that after fixation of the tendon in the groove there was rapid relief. It appears, however, from his clinical descriptions that few of these cases had the characteristic features of true "frozen" shoulder. In many of them the signs were those that we regard as typical of bicipital tendinitis—namely, pain in the shoulder and down the arm, tenderness over the bicipital groove, positive biceps tension test, and pain at the extremes of movement with or without a few degrees loss of movement. Our own view is that although biceps peritendinitis occurs as a primary lesion, causing shoulder pain which may simulate "frozen" shoulder, it is unusual for active or passive movements to be limited by more than a few degrees. Recovery from this type of painful shoulder might be hastened by anchoring the biceps tendon but the operation has no general application to all cases of "frozen" shoulder.

Secondary biceps peritendinitis—If there is a supraspinatus tear of sufficient size to impair stability of the humeral head the long head of the biceps acts as a fixator of the humeral head, though no doubt rather inefficiently. One of our patients who had signs of a supraspinatus tear found that he could abduct his arm only if he first increased biceps tension by full supination. At operation he had a large, recent, anterior supraspinatus tear; the biceps tendon, where it was exposed to injury by contact with the acromion, was inflamed. Other examples of biceps tendinitis associated with lesions of the supraspinatus have been encountered. Thus it seems that, when the long head of the biceps takes over the function of a fixator of the humeral head, the resulting strain and friction render it liable to secondary peritendinitis.

Treatment—*Primary biceps peritendinitis* usually recovers spontaneously if the limb is rested. In resistant cases, when the disability is severe, the tendon should be sutured to its groove distal to the joint, the intra-articular portion being excised. Recurrent dislocation of the biceps tendon should be treated in the same way. *Secondary peritendinitis*—If secondary peritendinitis is due to a torn supraspinatus, and the tear is judged to be capable of healing after suture, the supraspinatus should be sutured and the biceps tendon excised, the stump being anchored in the groove. If the cause is an attrition defect, or a tear judged unsuitable for suture, the biceps tendon should be excised and its stump anchored; in these cases some loss of function must be expected. Lippmann (1943 and 1944) recommended fixation of the biceps tendon in the groove leaving the tendon in continuity. This should give relief but not cure, because the useless intra-articular portion of the tendon buckles on movement and may act as a loose body. Excision of the intra-articular portion of the biceps, unless done blindly with a stripper, necessitates a small incision in the cuff. This cut should be made in the line of pull so that sutures are unnecessary and there is minimal danger of producing a painful shoulder from inflammatory reaction in the supraspinatus tendon.

THE PAINFUL ARC SYNDROME

The painful arc syndrome, which is sometimes associated also with constant aching, is occasionally due to bicipital peritendinitis or bursitis, but is usually due to local areas of degeneration in an otherwise healthy supraspinatus tendon, with low grade inflammatory reaction which causes pain. This local inflammation may be perpetuated by contusion of the tendon against the acromion. We have observed the late results in thirteen patients, the average age being thirty-eight years, although as a rule the syndrome occurs between the ages of forty and forty-five years. Three of five patients treated conservatively still have pain and weakness. Six of eight patients who were treated by excision of the acromion process have normal shoulders, the average pre-operative disability period being five years, and

the time necessary for full recovery after operation six months One patient has a full range of movement and normal power after operation but complains of occasional pain, and the other unsatisfactory result of operation was in a patient who was greatly improved for nine months but then developed persistent signs of bicipital peritendinitis

Calcification of the supraspinatus tendon—There are three clinical types of calcification of the supraspinatus tendon In the first, the calcified deposit is entirely symptomless and is discovered incidentally The second is characterised by aching pain in the shoulder and a painful arc of movement during abduction, there is localised inflammatory reaction but not enough tension to cause severe pain these deposits remain in the substance of the tendon and as a rule they are slowly absorbed In the third type there is very intense pain due to tension caused by the acute inflammatory reaction with muscle spasm Often the tension is so great that rupture occurs either into the bursa or deep to it When the tension is released, recovery is usually complete within a few weeks Radiographs show the calcium deposit changing in position and shape and, as one would expect with a severe vascular reaction, the calcium disappears rapidly

SUPRASPINATUS TEARS

In deciding whether or not to attempt suture of a ruptured supraspinatus tendon several points need to be considered 1) The large tear, which causes instability of the humeral head, is rare, but, unless it is repaired, permanent disability is almost certain 2) Retraction of the torn tendon increases, the longer suture is delayed 3) Suture of a grossly degenerated tendon is unlikely to be successful 4) Under experimental conditions rupture seldom if ever occurs in a tendon unless it is degenerated (Wilson 1943, Lindblom 1939, Cronkite 1935, McMaster 1933) In the living shoulder conditions are different, in so far as the supraspinatus tendon may be pinched between the humeral head and the acromion process at the same moment that the muscle is strongly contracted, so that tears may occur in young patients with only slightly degenerated tendons 5) Suture of a supraspinatus tear may produce just those conditions which give rise to the "frozen" shoulder with a post-operative course that is painful and prolonged 6) Secondary biceps tendinitis may be coincidental with defects in the supraspinatus tendon, perhaps especially when the groove in which the tendon lies is narrowed by suture

The diagnosis of supraspinatus tears depends upon the fact that the supraspinatus is the chief fixator of the humeral head in abduction, the infraspinatus, subscapularis and biceps being relatively inefficient and capable only of stabilising the head against weak deltoid contraction Provided pain has been relieved, the stability of fixation and power of abduction at the gleno-humeral joint is directly proportional to the amount of supraspinatus tendon still intact Large tears with retraction are easy to diagnose because there is sudden onset of almost painless loss of function, often accompanied by a snap, with no restriction of passive movement but with total loss of the power of initiating abduction More limited tears are difficult to differentiate from shoulder sprains, and small tears cause no appreciable weakness, pain being the dominant symptom The differentiation is aided by noting the initial rhythm of abduction after procaine infiltration If pain has been relieved, and the deltoid is acting strongly, disturbance of the initial rhythm (which normally is characterised by very little scapular movement during the first thirty degrees of abduction movement of the limb—and with no elevation of the shoulder) indicates instability of the humeral head and a supraspinatus tendon tear of considerable size

Treatment of supraspinatus injuries—*Small tears* which are not the cause of instability cannot be distinguished clinically from sprains Treatment should be by local heat, non-gravity exercises, and local injection of procaine In this type of injury it may be impossible to prevent later development of the "frozen" shoulder syndrome *Moderate tears* causing instability should usually be sutured With or without suture, a "frozen" shoulder may

develop, but the ultimate prognosis ought to be better with suture *Large complete tears* with retraction should be sutured if the expectation of life and capacity for work is good In old patients who are unlikely to work again operation is inadvisable and the disability should be accepted

Excision of the acromion process and biceps tendon in operations upon the supraspinatus—Routine excision of the intra-articular portion of the biceps tendon has two advantages the possibility of later development of the bicipital syndrome is avoided, and the removal of an unnecessary and bulky structure from between the head of the humerus and the vulnerable area of the supraspinatus tendon reduces the likelihood of impingement against the acromion process and the coraco-acromial ligament Our autopsy investigations indicate that this ligament is a strong and unyielding structure against which the anterior third of the supraspinatus insertion impinges when the efficiency of the supraspinatus is impaired Impingement of the tendon against either the coraco-acromial ligament or the acromion itself is relieved when the acromion process is removed as far proximally as the acromio-clavicular joint

SUMMARY

1 The "frozen" shoulder syndrome is due to an inflammatory lesion in the musculo-tendinous cuff invoked by a local area of degeneration

2 The available evidence suggests that the primary site of the degenerative lesion is in the supraspinatus tendon

3 Other causes of shoulder pain which must be differentiated from "frozen" shoulder are peritendinitis of the long head of biceps, degeneration or tears of the supraspinatus, and calcified deposits in the supraspinatus

4 An explanation of the pathogenesis of lesions of the musculo-tendinous cuff is submitted in which the different types of clinico-pathological syndrome are correlated This hypothesis is in accord with the experimental, clinical and operative findings

My thanks are due to Mr A E Clark of St Thomas's Hospital for his technical work in preparing the sections and photomicrographs I am grateful to Professor W G Barnard for his opinions on the sections and to Professor George Perkins for his stimulation and interest

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PAINFUL SHOULDER

Calcification of the Supraspinatus Tendon

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There is a particular type of painful shoulder that has been recognised as a clinical entity but in which the occurrence of spontaneous recovery has not been emphasised sufficiently. The onset of pain is sudden, very severe, and not usually precipitated by injury, often starting during simple movement of the arm or even by turning over in bed. All movement is limited by pain and muscle spasm and the limb is held rigidly to the side; there is inability to rest or sleep and some patients have become mentally strange after several days of such pain. Radiographs taken shortly after the onset of symptoms show calcification in the area of the supraspinatus tendon.

The condition is uncommon; it occurred in 1 per cent. of three hundred painful shoulder lesions reviewed at the Princess Elizabeth Orthopaedic Hospital, Exeter. Six cases are presented (Table I) in which the treatment consisted of simple rest with heavy sedation to assure sleep, followed by active movements within the limits of pain as symptoms subsided.

TABLE I

ANALYSIS OF SIX CASES OF CALCIFICATION OF THE SUPRASPINATUS TENDON, AND ONE OF CALCIFICATION IN TENDON NEAR THE HIP JOINT

Sex	Age	Occupation	Duration of symptoms	Calcification in first radiograph	Recovery of full movement	Full function	Disappearance of calcification in radiograph	Total duration of disability
M	30	Army Officer	7 days	Dense	14 days	21 days	21 days	28 days
F	40	Housewife	14 days	Dense	28 days	36 days	4 months	50 days
M	49	Clerk	2 days	Dense	36 days	42 days	3 months	46 days
M	30	Hotel Manager	2 days	Moderate	7 days	14 days	3 months	16 days
F	35	Housewife	2 days	Moderate	15 days	15 days	15 days	17 days
F	48	Housewife	6 days	Moderate	16 days	16 days	16 days	22 days
M	29	Army Officer	1 day	Dense (Hip joint)	15 days	28 days	28 days	28 days

Spontaneous recovery with absorption of the calcified deposit took place in fourteen to twenty-eight days and there has been no recurrence in a follow-up period of six months to five years. One case of a similar lesion of the hip joint is added because it presents the same clinical and radiographic features. Illustrative radiographs are shown in Figures 1–8.

* *Paper read at the Annual Meeting of the British Orthopaedic Association, 1948.*

FIG 1

January 1 1945

FIG 2

January 20, 1945

Case 1 Male, aged 36 years At the time of onset of acute pain and muscle spasm a dense opacity was shown in the radiograph (Fig 1) Three weeks later, after simple rest, the radiographic appearances of calcification in the tendon had almost completely disappeared (Fig 2)

FIG 3

FIG 4

Case 2 Female aged 40 years Figure 3 shows the condition fourteen days after the acute onset of symptoms There was rapid improvement with rest Radiograph four months later shows disappearance of the calcified deposit (Fig 4)

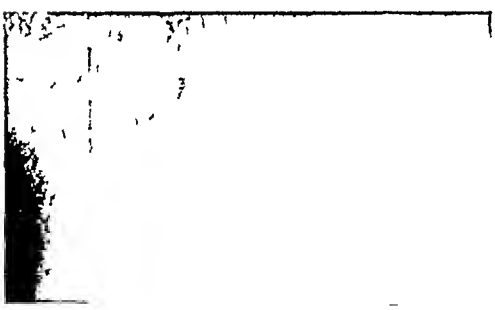

FIG 5

FIG 6

Case 3 Male, aged 49 years Figure 5 is the initial radiograph taken at the time of first onset of symptoms showing an extensive calcified deposit Within four weeks the opacity was of diminished intensity and after ten weeks absorption of the calcified deposit was almost complete (Fig 6)

FIG 7

FIG 8

Case 4 Male, aged 30 years Figure 7 shows an opacity of moderate density Three months later the radiographic appearances were normal (Fig 8)

Discussion—There is a vast literature dealing with calcification around the shoulder joint Codman (1934) gave a clear description of such deposits in the sub-deltoid bursa, and it has been recognised that this lesion is capable of spontaneous recovery Nevertheless reports are still published which claim benefit for a particular treatment Injection therapy is one such method For example, Patterson and Darrach (1937) described a technique of removing the deposit by irrigation through two or more needles Relief was obtained despite the fact that radiographs "sometimes show apparently the same amount of calcium after irrigation as before" Lapidus (1943), after reviewing the literature, presented a series of sixteen cases with acute symptoms together with sixteen cases in which other joints were affected He found that treatment by infiltration with local anaesthetic and injection of saline into the calcified deposit caused relief of the symptoms and disappearance of the calcification soon afterwards While recognising that the condition was capable of spontaneous recovery he concluded that injection therapy was beneficial Recently, Norwich (1948) reported fifteen cases in which rapid recovery took place after injection therapy

FIG 9

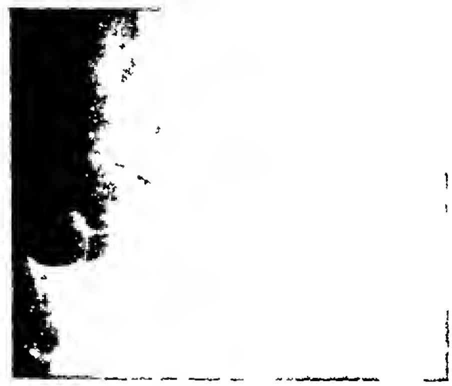

FIG 10

Case 7 Male aged 29 years Calcification in tendon near the hip joint shortly after the onset of symptoms (Fig 9) The symptoms subsided gradually during rest in bed and four weeks later the area of opacity is greatly diminished (Fig 10)

This writer believes that proper assessment of the natural repair processes in acute cases has not been made Relief of pain can be obtained by simple rest and sedation without the added risk of infection by injected fluids Objectively the recovery with such treatment has been as rapid and complete as that reported after injection therapy Reactive hyperaemia after rupture of the deposit into the sub-deltoid bursa probably accelerates absorption and repair Thus the more acute the symptoms, the more rapid the spontaneous cure

SUMMARY

1 The explosive type of painful shoulder due to rupture of a calcified deposit into the sub-deltoid bursa is described

2 A brief report of six cases is presented

3 No treatment other than rest and sedation is needed

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EXCISION OF THE ACROMION IN TREATMENT OF THE SUPRASPINATUS SYNDROME

Report of Ninety-five Excisions *

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The majority of patients who complain of a painful shoulder are suffering either fr[om] periarthritis, "frozen shoulder," or from a supraspinatus lesion Lesions of the supraspina[tus] tendon at or close to its insertion, where it is intimately associated with the subacrom[ial] [bu]rsa give rise to a characteristic combination of symptoms—the supraspinatus syndrom[e] —which are mechanical in origin In the middle range of abduction movement the tendo[n] impinges on the overlying processes and the tendon and bursa are compressed between th[e] humerus and acromion (Fig 1) When there is abnormality of the tendon or bursa th[e] pressure causes pain, and any movement which tends to bring the lesion into contact with [t]he acromion causes reflex muscle spasm The supraspinatus syndrome is usually character[i]stic, although in its later stages it may be complicated by true limitation of shoulder movement, due partly to disuse and partly to adhesion formation in the region of the sub acromial bursa, which masks the typical symptoms and complicates both diagnosis and treatment

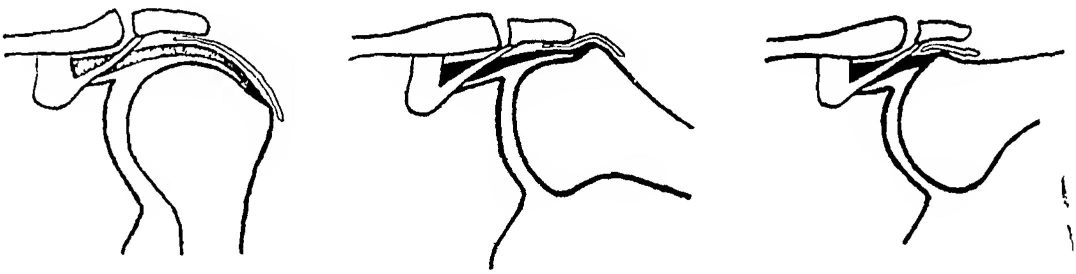

FIG 1

In the middle range of abduction the supraspinatus tendon and subacromial bursa are compressed between the upper end of the humerus and the acromion

The results of conservative treatment—Most patients with the supraspinatus syndrome recover either spontaneously or after conservative treatment Many measures have been advocated and good results have been reported with each of them It is probably true that about 90 per cent of patients with this condition get well in a few weeks In the remaining 10 per cent, symptoms persist stubbornly for many months in spite of such treatment as rest, physiotherapy, manipulation, active exercises, infiltration with local anaesthetic or deep X-ray therapy, and it is in this group of cases that excision of the acromion is indicated

THE AIMS AND PRINCIPLES OF EXCISION OF THE ACROMION

The principle underlying excision of the acromion is simple Intermittent pres[s]ur[e] associated with abduction or forward flexion of the arm causes pain and muscle spasm, ar[id] constantly repeated irritation prevents healing of the lesion Excision of the acrom[ion] relieves this pressure A full range of painless shoulder movement then becomes poss[ible] and most of the symptoms disappear by the time the patient has recovered from the immed[iate] effects of the operation When relieved of irritation, the underlying condition slowly re ol[ves] or heals

* *Based on a paper read at the Annual Meeting of the British Orthopaedic Association in Belfast October 1*

To ensure successful results a considerable amount of bone must be removed This point was not at first appreciated and in the first nine cases in this series not enough of the acromion was excised, in attempting to preserve the acromio-clavicular articulation the bone was divided immediately lateral to the joint (Fig 3) At operation there appeared to be adequate clearance but the results were unsatisfactory in five of these patients The upper end of the humerus lies slightly anterior to, rather than immediately below, the

FIG 2

After excision of the acromion four and a half years previously the bone has reformed almost completely

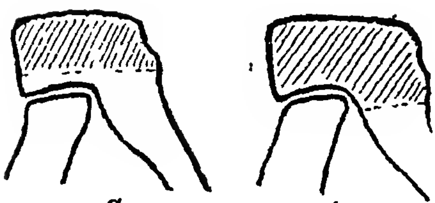

FIG 3

Excision of bone distal to the acromio clavicular joint (Fig 3a) is not always satisfactory It is better to remove the acromion completely (Fig 3b) because otherwise new bone may form in the attachment of the deltoid to the raw bone surface

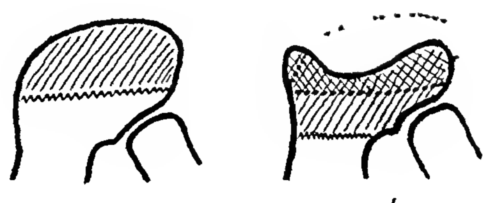

FIG 4

Fig 4a is a tracing of the line of first excision of the acromion in the case shown in Fig 2 New bone that formed within a few months (Fig 4b) necessitated a second operation for complete excision at the joint level

acromion process and the insertion of the supraspinatus tendon comes into contact with the anterior part of the process on shoulder movement In fact Codman suggested that it was contact with the coraco-acromial ligament rather than with bone that caused the pressure In any event it is essential that the anterior part of the acromion should be removed completely and any attempt to preserve the acromio-clavicular joint may cause unsatisfactory results Moreover, when the acromion has been divided and the detached deltoid muscle is sutured to its cut edge, new bone formation takes place rapidly and symptoms may recur (Figs 2–4) If the whole of the acromion process lateral to the acromio-clavicular joint is

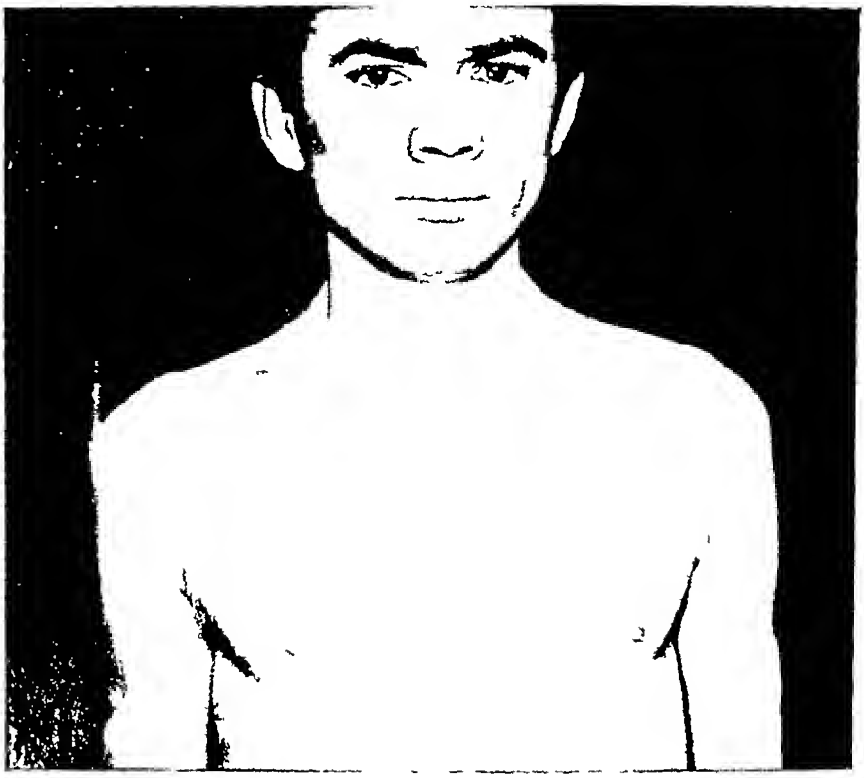

FIG 5

FIG 6

FIG 7

Photograph of patient four months after complete excision of the right acromion (Fig 5) and radiograph of the right shoulder (Fig 6) and the left shoulder (Fig 7) The difference in contour of the shoulder is scarcely noticeable

removed, the end of the clavicle constitutes the new attachment to which the deltoid i sutured, so that no raw bone is exposed in the area in which new bone formation would b harmful

Complete excision of the acromion does not appear to cause untoward effects If th conoid and trapezoid ligaments are undamaged, loss of the acromio-clavicular joint is r associated with any disability The cut edge of the deltoid muscle, sutured firmly to t coraco-acromial ligaments, forms a firm fibrous scar which gives support to the outer end the clavicle The operation does not result in any serious cosmetic blemish The scar is course visible and may tend to stretch a little, but the alteration of contour is not noticeat (Figs 5 and 6) The posterior angle of the cut edge of bone should be rounded off so that spike is left

INDICATIONS FOR EXCISION OF THE ACROMION

Broadly speaking, excision of the acromion is indicated in treatment of the supraspinatus syndrome whenever conservative treatment has failed More precise indications vary according to individual opinion and they depend upon a number of circumstances The most important single factor is the duration of symptoms Lesions of the supraspinatus group tend to resolve and subside with time, and operation is never a matter of urgency Indeed some surgeons maintain that all these lesions recover spontaneously over a period of one or two years, but even if this were true, which is to be doubted, few patients are prepared to tolerate symptoms for so long a time, nor is it reasonable to expect them to do so On the other hand it is impossible to tell in the early stages which patient will recover and which will require operation Conservative treatment should always be tried for at least two months, and only if there is no improvement at the end of that time should operation be considered

When, as is often the case, symptoms improve to some extent without being completely relieved, other factors must determine whether or not operation should be advised The severity of the symptoms and the degree of associated disability are obviously important In its initial stages the acute syndrome may be acutely painful and crippling, but this phase does not often persist The typical syndrome is neither very painful nor completely incapacitating and its effects often depend on the age, occupation and mode of life of the patient A painful arc of movement may be no more than a mild nuisance to an elderly patient of sedentary habits and yet be a severe handicap to a younger person whose occupations are strenuous Discomfort, accepted philosophically by one with a phlegmatic temperament, may be devastating in its effects on a more highly strung patient Each patient who does not respond to conservative treatment provides an individual problem, and the surgeon's attitude to operation will certainly be influenced profoundly by his opinion of its efficacy

There are two circumstances in which excision of the acromion is contra-indicated When there is true limitation of shoulder movement, operation produces a stiff and stubborn joint which requires months of treatment before mobility is restored Muscle spasm can be distinguished from adhesion formation by examination after the lesion has been infiltrated with local anaesthetic or, better still, by examination under a general anaesthetic If there is true limitation this must be dealt with by active exercises, and perhaps manipulation, before operation is contemplated Operation is also contra-indicated if there is doubt as to the diagnosis Removal of the acromion will relieve pressure on the supraspinatus tendon or subacromial bursa but if applied in a haphazard manner to the treatment of all stiff painful shoulders the operation gives very unsatisfactory results, particularly in patients with periarthritis

RESULTS

In 1939, Watson-Jones first reported excision of the acromion in the treatment of supraspinatus tendon lesions at a meeting of the British Orthopaedic Association in Oswestry, and he described the procedure in 1943 At about that time this writer was becoming increasingly dissatisfied with the results of conservative treatment in many service patients who were under treatment at the Royal Air Force Hospital, Rauceby Those who were not promptly relieved by conservative treatment were often incapacitated for long periods and there seemed nothing else to offer After trial of excision of the acromion the results were encouraging, particularly when experience had shown that it was necessary to excise the whole of the acromion Conviction that the operation was a good one was strengthened by personal experience In 1944, after several months of typical incapacity which had persisted unchanged despite all forms of conservative treatment, my own acromion process was excised by Sir Reginald Watson-Jones with complete and permanent cure The results in a personal series

of ninety-five patients are summarised in Table I Because many of these patients were referred for operation after conservative treatment elsewhere had failed, it is not possible to state the proportion that they represent of all patients suffering from the supraspinatus syndrome

In eighty of ninety-five patients the operation was completely successful, they were relieved of symptoms and regained a full range of powerful shoulder movement In the first nine operations the acromion was divided far enough laterally to preserve the acromio clavicular joint Five of these patients gained incomplete relief or none at all In three patients further excision of bone gave good results Two re-excisions were carried out about two months after the original operation, the third patient gained initial relief from the first operation but symptoms then recurred and at the time of re-excision seven months later new bone formation was obvious In the other two unsuccessful cases permission for further operation was refused, one patient was satisfied with the incomplete relief he had gained, the other was discouraged by the unchanged persistence of his original symptoms In six instances the result of operation was unsatisfactory because there was post-operative

TABLE I
RESULTS OF OPERATION

Results of Excision of the Acromion in Ninety-five Patients suffering from the Supraspinatus Group of Lesions	
Satisfactory to patient and surgeon	80 (84 2 per cent)
Unsatisfactory	15 (15 8 per cent)
Analysis of Fifteen Unsatisfactory Results	
Insufficient bone removed	5 (In three patients a further excision was successful)
Post-operative limitation of movement	6
No relief of symptoms	4

limitation of shoulder movement, there was complete relief of pain but the range of forward flexion and abduction movement was reduced by about one-third and the patients, being content with relief of pain, were unwilling to be stimulated in making the endeavour needed to regain a normal range of movement Four patients said that they had gained no relief at all in two the original diagnosis may have been inaccurate, and in the other two failure of the operation is still unexplained

PATHOLOGICAL FINDINGS AT OPERATION

The subacromial bursa was opened at operation in every case and the pathological findings were noted The various conditions that were seen were not always distinctive different, one from the other Nevertheless it seemed possible to classify them into fo[ur] groups (Table II)

Fifty-six patients appeared to have tendinitis with an associated bursitis The tend[on] was red, thickened and rough, and the bursal walls and synovial lining were oedemato[us]

and inflamed, these changes being most marked around the tendon In recent and acute cases the synovial membrane hung in red, oedematous folds The changes suggested that tendinitis was the primary lesion and bursitis secondary

In ten patients the primary lesion appeared to be subacromial bursitis The walls of the bursa were red, thickened and adherent to the acromion, the cavity contained free fluid and, in a few instances, small loose bodies The changes were uniform, and not in any way localised to the region of the supraspinatus tendon, and they were exactly similar to those of a chronically inflamed prepatellar or olecranon bursa

In fifteen cases calcified deposits in the supraspinatus tendon were visible in the pre-operative radiographs At operation the tendon appeared rough, thickened, opaque and slightly red, and there was evidence of localised bursitis No attempt was made to remove the deposits from the tendon

Tears of the supraspinatus tendon were found in fourteen patients Most frequently the tendon was incompletely detached from its insertion The area of detachment was small and not associated with retraction such as occurs after complete rupture Occasionally small rents were observed in the tendon itself through which the articular cartilage of the humeral head could be seen

TABLE II

PATHOLOGICAL FINDINGS

Pathological Findings in Ninety-five Patients with the Supraspinatus Syndrome	
Tendinitis with secondary subacromial bursitis	56
Primary subacromial bursitis	10
Calcification in supraspinatus tendon	15
Tears or detachments of supraspinatus tendon	14

OPERATIVE TECHNIQUE AND POST-OPERATIVE MANAGEMENT

Certain points in the technique, which make the operation easier, are worthy of note The patient is laid on the sound side with the head well flexed The surgeon sits at the top of the table, the arm being controlled by an assistant The incision begins in front of the acromio-clavicular joint and extends back across the joint and acromion in a direction slightly concave outwards A flap of skin and subcutaneous tissue is then raised, exposing the upper surface of the acromion and joint The periosteum is divided about half an inch lateral to the proposed line of section and reflected inward The acromion is divided from before backwards with a sharp osteotome held very obliquely to avoid the possibility of damage to underlying structures The line of section should extend directly backwards from the acromio-clavicular joint When the acromion has been divided it is held in lion forceps while the deltoid origin is detached from its outer edge, working from behind forwards The subacromial bursa is usually found to be adherent and must be dissected from the deep surface of the bone The last structures to be divided are the acromio-clavicular and coraco-acromial ligaments

After removal of the acromion the bursa is opened for examination, and the underlying tendon is inspected, the arm being abducted and rotated as necessary The bursal wall is closed The cut edge of the deltoid is sutured firmly to the acromio-clavicular ligaments and reflected periosteum or, if necessary, to the bone itself through holes drilled with an awl The deltoid is repaired while the limb is held in abduction and security of the suture-line is then tested by lowering the arm to the side The skin is sutured and a pressure bandage applied

During operation some generalised arteriolar bleeding occurs, but no large vessels are encountered and few ligatures are necessary It is very much easier and quicker to remove the acromion in this retrograde manner than to attempt to clear its muscle attachments and then to divide the bone The acromion should always be cut cleanly with a sharp osteotome, never be nibbled away piecemeal

Post-operative management—After operation it is unnecessary to immobilise the limb in abduction The patient wears a sling but is encouraged to use the forearm and hand as much as possible Passive movements of the shoulder are permitted, the arm being placed in the most comfortable position or rested on a pillow The patient need be confined to bed only for four or five days Active movements of the shoulder are not attempted for ten days after operation during which time contraction of the deltoid is painful, but after this interval gentle shoulder exercises should be encouraged, particular attention being paid to abduction In the early stages exercises are best tolerated in the supine position which minimises the effects of gravity, and it is advisable to continue abduction exercises in this position until a full range has been regained

There is of course much variation in the rate of recovery of different patients An active man may play golf without difficulty within four weeks of operation, but most patients need six to eight weeks before they are able to use the shoulder with confidence The last ten degrees of abduction and forward flexion movement are regained slowly, and very often, since the patient may not appreciate that there is still some limitation of movement, it is difficult to persuade him to persist assiduously with the necessary exercises

Acute symptoms are at once relieved by the operation but often there is slight aching, especially at night, for several months The cure may be regarded as complete when the patient has not only regained a full range of movement but is also able to sleep comfortably at night on the affected limb

CONCLUSIONS

1 The supraspinatus group of lesions constitutes one of the two common causes of the painful shoulder

2 Most, but not all, of these lesions resolve either spontaneously or after conservative treatment

3 When conservative treatment fails symptoms can be relieved by excision of the acromion process, provided that sufficient bone is removed to relieve all pressure on the tendon throughout a full range of shoulder movement

4 Excision of the acromion is contra-indicated if there is doubt as to the diagnosis or if there is true limitation of shoulder movement

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VITAMIN E THERAPY IN DUPUYTREN'S CONTRACTURE

Examination of the Claim that Vitamin Therapy is Successful

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From the Orthopaedic and Accident Department, The London Hospital

It has been claimed that striking success can be gained in the treatment of Dupuytren's contracture of the palmar fascia by simple oral administration of vitamin E in high dosage It has been said that, after such treatment, thickening of the fascia disappears and contracture of the fingers is relieved Le Roy Steinberg (1947) used daily doses of 300 mg of mixed natural tocopherols (of which 60 per cent is in the form of alpha-tocopherol) for a few weeks until maximal effect was gained A daily maintenance dose of 1 mg per kilo of body weight was continued thereafter

Such a claim of success from so simple a treatment warranted careful investigation and a trial series of thirteen patients was studied in the Orthopaedic and Accident Department of the London Hospital The routine dosage was 100 mg of pure synthetic alpha-tocopherol, three times a day, given in the form of Roche " Ephynal Forte " 20 mg tablets The aim was to continue treatment for about three weeks, or " until maximal improvement had been gained," and thereafter to give a smaller maintenance dose In seven patients we succeeded in giving heavy doses for periods ranging from four to eight weeks, in four the treatment was abandoned during the third week, and in two it was abandoned during the first few days

Four patients complained of headache, nausea, fatigue, drowsiness, " singing-in-the-ears," " swelling of the tongue," giddiness, blurred vision, sweating, and other symptoms that made it impossible to continue The other nine patients made no such complaints, and four of them were quite sure that they had gained improvement One, with a moderate degree of contracture, said " the band feels softer " Another, with deformity of moderate degree, said the fingers feel straighter and the aching pain has gone " Two others had severe deformity and both insisted that " there is improvement " but were unable to specify the nature of the improvement

The effects were checked in every case by detailed clinical records, accurate measurement of deformity, and serial clinical photographs In twelve of the thirteen patients there was no evidence whatever of any alteration In one, with moderate deformity, we think that after the second week of treatment the finger was somewhat straighter and the palmar thickening somewhat softer Review one year later (after five weeks of full dosage and three weeks of maintenance dosage) shows that he still has moderate deformity In the other twelve, including those treated on full dosage for six to eight weeks (at a cost of £5 a week), we can see no change The treatment has been abandoned

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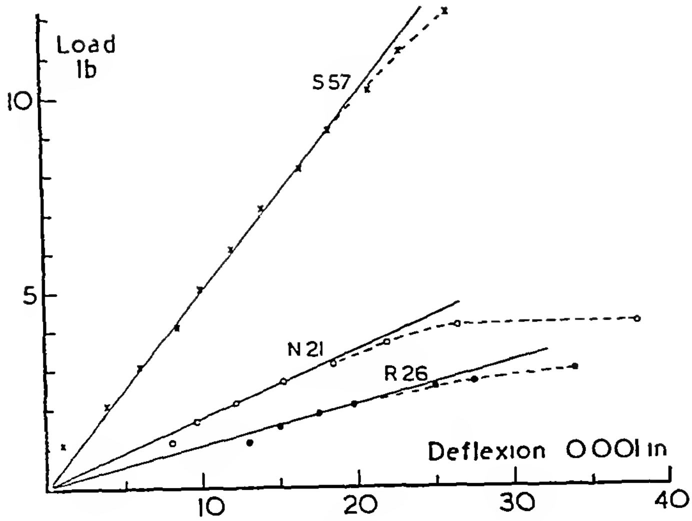

FIG 3

Load-deflexion diagrams for three typical bones one from each group Group R = • group N = o, group S = x

appreciably when the bone is loaded then a small "end-correction" can be made and the formula becomes –

$$E = \frac{Wl^3}{48Iy}\left\{1 - 8\left(\frac{c}{l}\right)^3\right\} \qquad (4)$$

Even in an extreme case, where c is $\frac{l}{4}$ and all the bending takes place in the middle half of the shaft of the bone, the correction is only 12·5 per cent. Thus, when correction for the part of the bone embedded in the semi-cylindrical end-pieces is made, there can be only a small residual error due to increase in the size of the shaft towards the ends

Chemical methods—After completion of the mechanical tests some of the femoral fragments were retained for X-ray crystallography The rest of the bone shaft was ashed in a crucible at full Bunsen heat Estimations of ash, Ca and P, were made as already described (Bell *et al* 1947)

RESULTS

Rats on the rachitogenic diet without supplement, group R, all showed gross evidence of rickets as judged radiographically by widening of the upper tibial epiphysis In group N, which received vitamin D in addition to the rachitogenic diet, the epiphysial lines were quite narrow In group S, on a good diet, the femora were nearly twice as heavy as those in group N Group R bones were about 20 per cent lighter than group N bones The average percentage ash content of the femora is shown in Table I The individual results are plotted in Figures 5 and 6 As diet improved the ash content of the bones increased The average length of group R femora was 2·0 cm , of group N, 2·4 cm , and of group S, 2·7 cm The scatter of results tended to be greater in group R, because the small size of the bones made measurements more difficult

The load-deflexion diagrams for three representative bones, one from each group, are given in Figure 3 The curve for group S bone is very nearly a straight line, except for the last quarter when the deflexion increases rather more rapidly than the load In the N and R specimens there is greater deviation from a straight line Over the straight part of each curve the deflexion is directly proportional to the load, the gradient of the curve indicates the stiffness (or resistance to deflexion) of the bone as a whole Since the bones are of different sizes these graphs cannot be compared directly and they give no indication

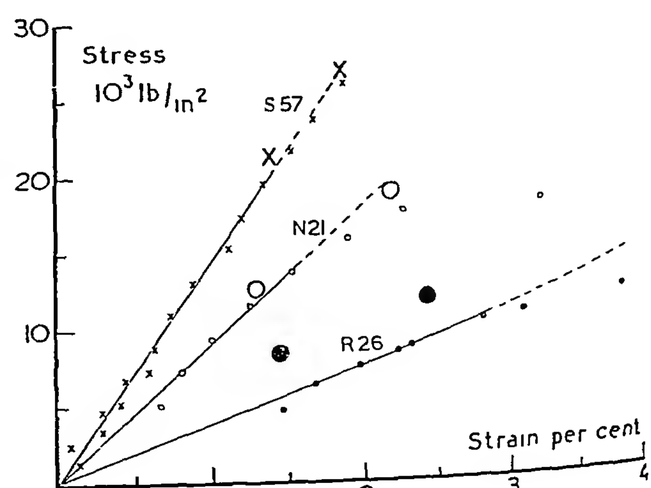

FIG 4

Stress-strain diagram of the three bones of which the load-deflexion curves are given in Fig 3 Group R = • group N = o group S = x The large symbols are placed at the average values for each group of the stress and strain at the elastic limit and at the point of rupture

The bending moment M, which measures the bending force on the bone as a whole, depends on the span as well as the load. At the centre of the span it is given by $M=\frac{Wl}{4}$. When the bone is loaded the upper surface is compressed and becomes concave, and the "fibres" of the lower surface are in tension and become stretched. For any given load the stress, or force per unit area on the bone substance, is greatest in the outer "fibres" at the centre of the shaft where the load is applied. It diminishes towards the ends. This value is given by —

$$\text{Stress} = \frac{MD}{2I} \text{ or } \frac{WlD}{8I} \qquad (1)$$

where I is the moment of inertia of the cross-section of the bone at the site of fracture. Since the cross-section is nearly elliptical, I is given by

$$I = \frac{\pi}{64}(BD^3-bd^3) \qquad (2)$$

As the load is increased, the stress at the centre increases until it reaches a maximum value at which the bone breaks. This maximum value is called the breaking stress on bending, and it is denoted by S_B.

The change in length per unit-length is called strain. Like the stress it is greatest in the outer "fibres" at the mid-point of the span, where it is given by

$$\text{Strain} = \frac{6yD}{l^2\left\{1-8\left(\frac{c}{l}\right)^3\right\}} \qquad (3)$$

The stiffness, or resistance to deflexion, of a bone depends on the size and shape of the cross-section and on the elastic quality of the bone substance. Young's modulus of elasticity, denoted by E, is a measure of the stiffness of the bone material. The stiffness of the bone as a whole is proportional to EI, and the flexibility or ease of bending is proportional to $\frac{1}{EI}$. The accepted formula for E, for a beam loaded at the centre, is $E=\frac{Wl^3}{48Iy}$ where I is the moment of inertia of the cross-section of the beam and y is the deflexion or sag at the centre. This formula is applicable only if the cross-section of the beam between the supports is constant but it can be applied, with slight modification, to the rat femur which is in fact somewhat thicker towards the ends. If a length c, at each end of the bone, is so supported by the semi-cylindrical end-pieces, or is so stiff as not to be bent

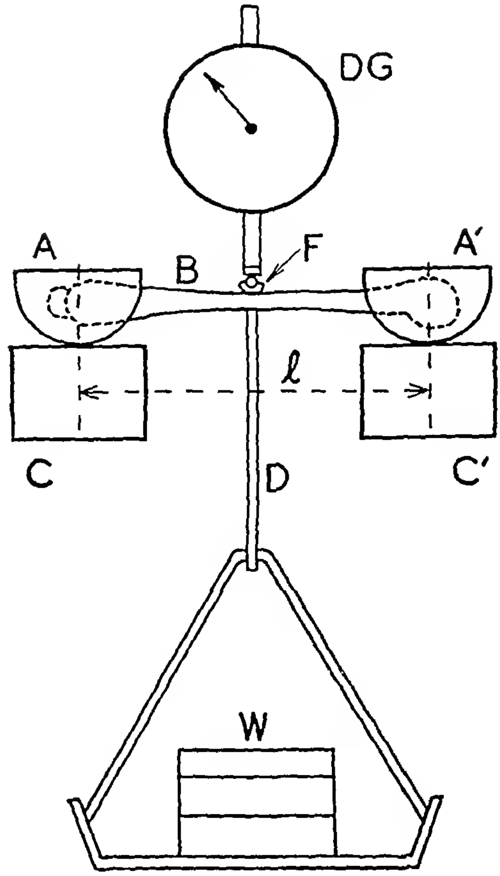

FIG 1

Apparatus for measuring elasticity and bending strength of bones. B bone. A, A′ semi-cylindrical ends cast on to bone ends. C, C′ supports. D, hook covered by layer of fibre F. W, load. DG dial gauge. l, span.

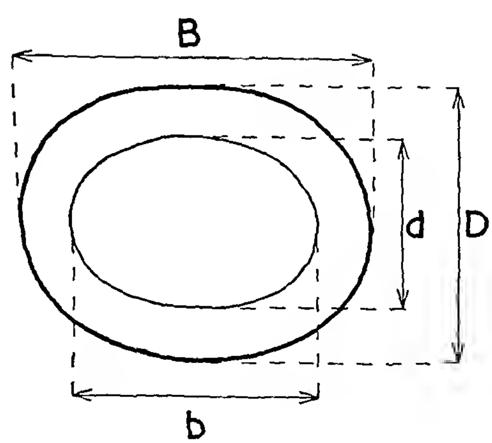

FIG 2

Cross section of rat femur at the mid-point of the shaft to indicate the measurements taken

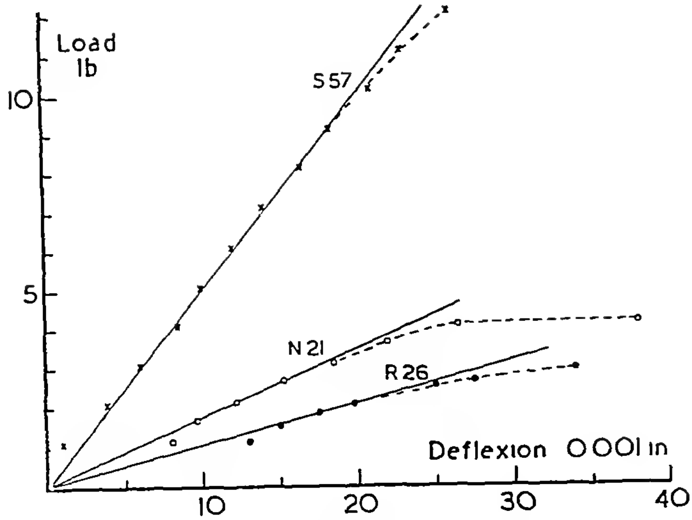

FIG 3

Load-deflexion diagrams for three typical bones one from each group Group R= • group N=o, group S=x

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The load-deflexion diagrams for three representative bones, one from each group, are given in Figure 3 The curve for group S bone is very nearly a straight line, except for the last quarter when the deflexion increases rather more rapidly than the load In the N and R specimens there is greater deviation from a straight line Over the straight part of each curve the deflexion is directly proportional to the load, the gradient of the curve indicates the stiffness (or resistance to deflexion) of the bone as a whole Since the bones are of different sizes these graphs cannot be compared directly and they give no indication

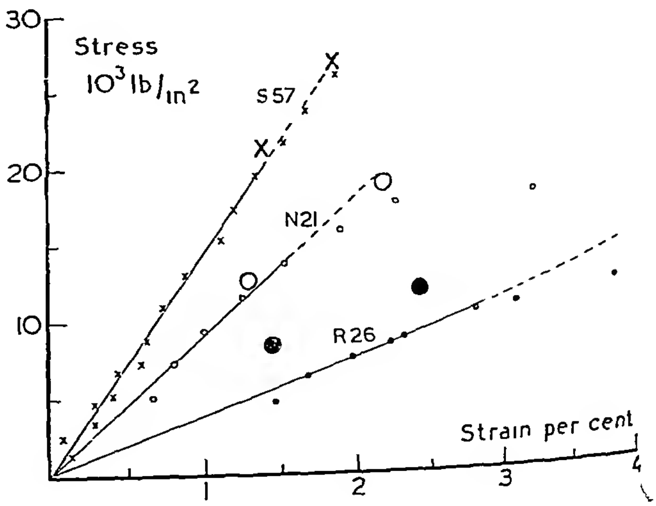

FIG 4

Stress-strain diagram of the three bones of which the load-deflexion curves are given in Fig 3 Group R= • group N=o group S=x The large symbols are placed at the average values for each group of the stress and strain at the elastic limit and at the point of rupture

of the quality of the material from which these bones are built Direct comparisons of the bone material can however be made from stress-strain diagrams Stress in the outer fibres is given by formula 1, and the strain by formula 3 These values have been calculated and are plotted in the stress-strain diagram Figure 4 The tangent of the angle made by the straight part of each curve (Fig 4), and the x axis, is E or Young's modulus The point at which the gradient begins to diminish indicates the upper limit of elasticity, beyond which plastic deformation occurs and ends in rupture The breaking point gives the stress and strain at which the bone begins to break

TABLE I

CHEMICAL AND PHYSICAL PROPERTIES OF BONES FROM RATS

R on a rachitogenic diet, N on a rachitogenic diet supplemented with vitamin D, and S on a complete diet

Group	No of animals	Average ash per cent	Average S_B 10^3 lb /in ^{2}	Average E 10^6 lb /in ^{2}	Average S_B / Average E $\times 10^?$	Average S_B/E $\times 10^?$	S D of $S_B/E \times 10^2$
R	12	37	11 9	0 64	1 85	2 04	0 65
N	19	43	18 9	0 99	1 90	1 91	0 20
S	6	59	26 9	1 56	1 73	1 74	0 11

TABLE II

PHYSICAL DATA FOR RAT BONES AT ELASTIC LIMIT AND AT RUPTURE

Group	R	N	S
Mean strain at elastic limit per cent	1 45	1 28	1 39
Mean strain at rupture per cent	2 41	2 18	1 84
Mean strain at elastic limit as percentage of mean strain at rupture	60	59	75
Mean stress at elastic limit 10^3 lb /in ^{2}	8 4	12 6	21 2
Mean stress at rupture 10^3 lb /in ^{2}	11 9	18 9	26 9
Mean stress at elastic limit as percentage of mean stress at rupture	70	67	79

While stress at the elastic limit is greater in bones with the higher ash content, strain is very much the same in all bones (Table II and Fig 4) At breaking point, the stress is again greater the higher the ash content, but there is a tendency for the strain at rupture to be higher in bones produced on the poorer diets, when the percentage of ash is low The differences which diet produces in E, S_B, and percentage ash, between the different groups of rats, are highly significant ($P<0\ 001$—Student's t test)

In order to study the relationship between breaking stress, elasticity, and chemical composition of the bone material, we have made three diagrams (Figure 5, 6, 7) Figure 5, already given by Bell, Chambers and Dawson (1947), illustrates the relationship between the breaking stress and the percentage of ash in the bones The diagram suggests that there is an association between breaking stress and percentage ash These are intrinsic qualities of bone material, and they are independent of the actual sizes of the individual bones The scatter diagram relating Young's modulus to percentage ash is very similar (Fig 6)

The relation between S_B and E was also investigated (Fig 7) A significant correlation was found within group N and group S taken separately The combined correlation coefficient for the three groups R, N, and S, even after elimination of the effect of diet, is +0 63, which is still highly significant Elasticity and breaking stress appear to be related more closely to each other than to the percentage of ash in the bone, but this is at least partly due to elimination of a source of variation common to both S_B and E, namely experimental error in determining the moments of inertia of the very small cross-sections of the bones Since the value of E is closely and positively correlated with the value of S_B, it is not surprising to find that there is no significant difference in the values of S_B/E in the three groups (Table I) The standard deviation of S_B/E is shown in Table I to give an idea of the scatter

To test the possibility that rupture of the bone depends on deformation rather than load we have attempted to estimate the ultimate strain when the bone was beginning to break The formula for the strain, formula 3, is accurate only to the elastic limit of the material Although the values obtained beyond this point cannot be regarded as absolute values, it seems justifiable to use them for comparative purposes These values, together with the corresponding stress values, are given in Table II

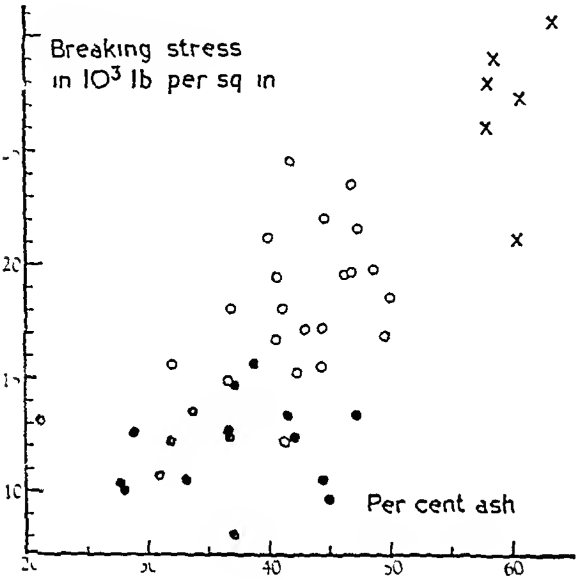

FIG 5

This diagram shows the breaking stress S_B plotted against percentage ash in the bone Group R = •, group N = o, group S = x Each point refers to one bone

CONCLUSIONS

One of the aims of this work was to find criteria by which the quality of bone as a supporting tissue might be judged This inevitably involves discussion and, if possible assessment, of the relative importance of the inorganic and organic material of the bone It is relatively easy to measure the mineral content, and for that reason it has always received more than its due share of attention

In the present experiment the composition of the ash of all bones was remarkably constant, with a Ca/P ratio of 2 Furthermore, X-ray crystallography showed that the structure of the inorganic material was the same in all cases The great difficulty of measuring variations in the quality of the organic material which is, of course, protein in nature makes it impossible to say how much it influences bone strength Since at least 40 per cent of the bone is collagen, either a quantitative or a qualitative alteration might alter bone strength X-ray crystallography revealed no qualitative differences in the collagen material of bones of the three groups so that for the present it would seem safer to assume that alterations in the physical properties of the bones are due to variations in the relative proportions of organic and inorganic constituents (Dawson 1946, Bell *et al* 1947)

These experiments show that the three diets produce highly significant differences in the percentage of ash, in S_B, and in E It is possible that some variations in the percentage of ash are due to variations in the absolute collagen (weight of collagen in unit volume of bone substance), but the range of variation in the percentage of ash leaves no reasonable doubt that differences in percentage ash between the diet groups are due essentially to differences in absolute ash Presumably the collagen contributes something to the strength of the bone, but the indications are that it plays a minor part and that the relative weakness and flexibility of rachitic bones is due to decrease in the absolute ash content Within a

one diet group, the relation between percentage ash and the other two variables, S_B and E, is masked by other sources of variation such as those associated with the many measurements involved, and thus the correlation between percentage ash and S_B, and also between percentage ash and E, is not significant

At first sight, the scatter diagrams (Figs 5 and 6) appear to indicate a correlation between ash and S_B, and between ash and E Closer inspection shows, however, that the apparent trend is due largely to differences between the means of the diet groups, and that the points within any one group show no such obvious trend Figure 7 shows that the position with regard to correlation between S_B and E is very different Here there is an obvious trend within each diet group, the amount of scatter is very much less Calculation shows that, even when the differences between the means of diet groups is excluded, there is still a significant correlation between S_B and E The question of the correlation between the three variables is discussed more fully in the addendum to this paper

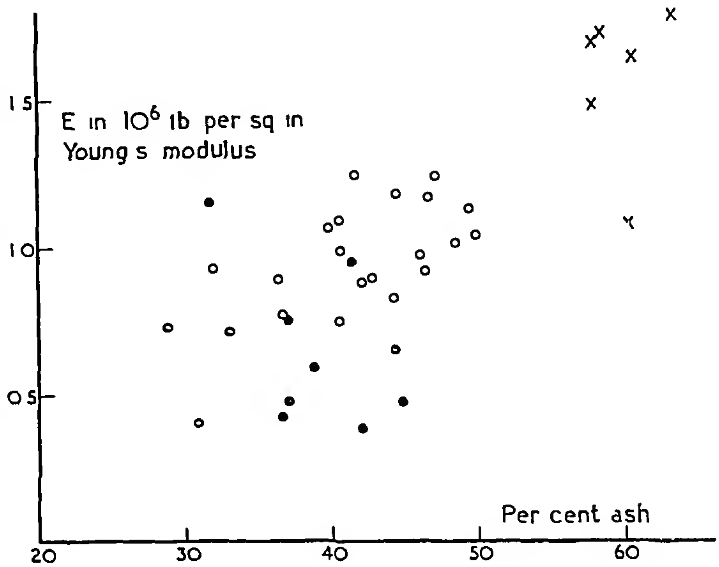

FIG 6

This diagram shows Young s modulus, E, plotted against percentage ash in the bone Group R=•, group N=o, group S=x Each point refers to one bone

Although the "goodness" of a bone is usually judged by its breaking stress, the experimental findings recorded above suggest that it may be assessed equally well on the basis of elastic properties as shown by Young's modulus Normal bones, group S in these experiments, were elastic up to 79 per cent of their breaking stress (Table II) the poorer bones of groups R and N were, however, only a little inferior in this respect In some cases there was no apparent deviation of the load-deflexion curve from a straight line until the bone was about to break Such a curve was published in the first paper of this series (Bell, Cuthbertson and Orr 1941), but in the light of further experience this curve is scarcely typical The terminal falling over of the curve is illustrated in Figure 4 and is much more marked in the bones of group R

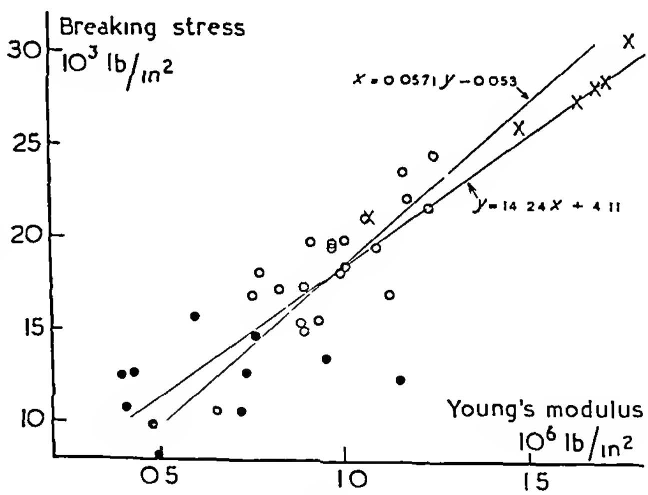

FIG 7

This diagram shows the relationship between breaking stress S_B and Young s modulus E Group R=• group N=o group S=x

While stress at the upper limit of elasticity varies over a wide range in the three groups (Table II and Fig 4), the strain at this point is remarkably constant at about 1 5 per cent This same percentage displacement must occur between the molecules of the bone material at

the elastic limit—and it may be that, up to this amount of molecular displacement, the deformation is reversible, but that beyond it, plastic changes occur We have no evidence as to whether the limiting displacement concerns mineral or protein constituents of the bone, or both

We have already commented on the remarkable strength of bone material (Bell et al 1941) The breaking stress of normal rat bone is about the same as that of cast iron, and about half that of mild steel Young's modulus, however, is only one-tenth that of cast iron and one-twentieth that of steel Thus bone, despite its lightness (specific gravity about 2, as compared with 7 9 for iron), is remarkably strong and at the same time more flexible than might be expected Presumably the biological advantage is that greater flexibility helps to absorb sudden impacts It is unusual in metallic substances to find the elastic moduli proportional to the strength, this is more characteristic of materials like concrete and timber Another remarkable property of bone is that it remains elastic up to three-quarters of the breaking stress Most metals show considerable ductility before reaching their breaking point

While Young's modulus is of interest, both on its own account and as an index of the quality of the bone, its close association with breaking stress suggests that it might be used to predict the maximum load which a bone can carry safely Since E, unlike S_B, can be measured without damage, useful information might be gained by measuring the elasticity of living human bones

ADDENDUM

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From the National Institute for Medical Research Hampstead, London

During analysis of the data presented in this paper an interesting observation was made of the effect of the combination of groups of results on the overall correlation coefficient If the three groups of observation—R, N and S—are considered, it is found that there is no significant correlation between ash and S_B, or between ash and E, in any one separate group If the groups were simple replicates of the same experiment, with all variables other than the two under investigation controlled, then combination of the data would be legitimate and the overall coefficient might reach a significant level owing to the larger number of observations concerned In this investigation, however, the three groups are not simple replicates of the same experiment but are in fact three different dietary groups Thus an additional variable, namely diet, has been introduced between the groups

It might be argued that diet has an effect upon only one of the variables concerned—for example ash—and does not change any other property of the bone This, however, is not known for certain The diet might, for example, affect the quality of collagen of the bones as well as their ash content In this way elasticity and breaking stress could vary independently of the ash content In the absence of any information on this question it seems highly undesirable to combine the data from the three groups without eliminating the effect of differences in diet

Statistical calculations—The total number of pairs of observations is in each case thirty seven combined correlation coefficient may be calculated from these figures which is appropriate to the thirty six degrees of freedom between them It will be seen however, that of these thirty six degrees of freedom two are attributable to differences between the means of the dietary groups and only the remaining thirty-four to total correlation when these differences are eliminated The total correlation for thirty-four degrees of freedom is readily obtained by summating the sums of squares used for the calculation of the correlation coefficients for each group separately, the degrees of freedom associated being eighteen in group N five in group S and eleven in group R This gives a total as before, thirty-four The results of these calculations are summarized in Table III It will be seen that there is always a highly significant correlation when the effect of diet is not eliminated but that only S_B and E are significantly related when this correction is made

Conclusion—These results are of general interest in that combination of data such as these may often be carried out without appropriate corrections and thus high and misleading values may be obtained for the correlation coefficient

TABLE III

Group		Degrees of freedom	Correlation coefficient	P	
Ash v E	R	11	−0 25	> 0 1	Not significant
	N	18	0 40	> 0 1	Not significant
	S	5	0 10	> 0 1	Not significant
Combined *		34	0 06	> 0 1	Not significant
Combined		36	0 73	< 0 01	Highly significant
Ash v S_B	R	11	−0 05	> 0 1	Not significant
	N	18	0 37	> 0 1	Not significant
	S	5	0 24	> 0 1	Not significant
Combined *		34	0 21	> 0 1	Not significant
Combined		36	0 76	< 0 01	Highly significant
S_B v E	R	11	0 30	> 0 1	Not significant
	N	18	0 76	< 0 01	Highly significant
	S	5	0 98	< 0 01	Highly significant
Combined *		34	0 63	< 0 01	Highly significant
Combined		36	0 90	< 0 01	Highly significant

* Corrected by elimination of effect of diet

SUMMARY

1 Three groups of one month old rats were fed for a period of four to five weeks on a rachitogenic diet (group R), the same rachitogenic diet with vitamin D (group N), and a complete diet (group S)

2 Young's modulus of elasticity E for bone can be derived from measurements of the deflexion of the centre of a femur loaded at the centre and supported at its ends

3 The three different diets produced significant differences in breaking stress S_B, Young's modulus E, and percentage ash in the bones It has not been shown conclusively that higher ash content alone is responsible for the greater S_B and E values of bones produced on the better diets

4 The value of E in group R was $0\,6\times10^6$ lb /in ^{2}, in group N $1\,0\times10^6$ lb /in ^{2}, and in group S (which can be taken as normal) $1\,6\times10^6$ lb /in ^{2}

5 There is a high correlation between S_B and E even when the effect of diet is eliminated

6 Although the bones produced on the good diet (group S) were much stronger than those of groups N or R, the strain at the elastic limit was the same (about 1 5 per cent) The strain at rupture tended to be higher in groups N and R than in group S

7 The properties of bone as a structural material are discussed

We are grateful to Dr I M Dawson for allowing us to quote the results of his X-ray examinations Figure 5 is reproduced by courtesy of the Editors of the Journal of Physiology We are greatly indebted to Dr W L M Perry for criticising the statistical treatment of our data and for contributing a most useful addendum The data in this paper may be converted to the metric system from the conversion factor 1000 lb /in ^{2} = 0 703 kg /mm ^{2}

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INNERVATION OF THE LIMBS

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In this paper the nerve supply of the limbs is considered under three headings the segmental supply of the skin, the segmental supply of limb muscles, and the double nerve supply of muscles *Segmental supply of the skin*—No new matter is presented but discussion of the dermatomes is included because restatement of the facts appears to be warranted by the misconceptions shown by many postgraduate students Moreover, study of the sensory segmental supply provides a convenient introduction to the consideration of motor segmentation to form a basis for comparison with the motor segmental supply *Segmental supply of limb muscles*—The conceptions here presented are new The scheme has been used by the author in clinical practice since 1923 That it is more than a mnemonic, and is a sound statement of anatomical fact, will be shown in the discussion *Muscles with a double nerve supply*—Apparent anomalies in the nerve supply of certain muscles are explained

SEGMENTAL SUPPLY OF THE SKIN

In all vertebrates the musculature of the body wall has a regular segmental motor innervation that for the most part corresponds with the overlying cutaneous segmental supply For example, the muscles of an intercostal space are supplied by the same spinal segment that innervates the skin over the space, and the dermatomes and myotomes of the thorax and abdomen are arranged in orderly sequence when traced from the cranial towards the caudal end of the trunk In the limbs, however, there is no such orderly sequence of segmental innervation, and in no sense could the dermatomes and myotomes be said to correspond

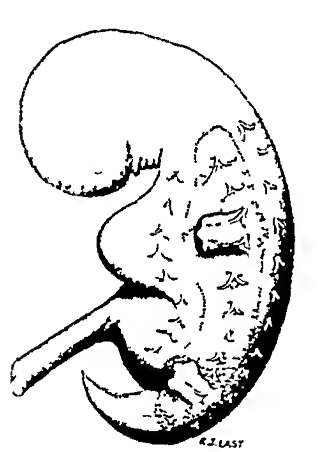

FIG 1

The three strips of body wall The limb buds emerge from the lateral strip (stippled in the diagram) innervated by the lateral branches of the mixed spinal nerves

Dermatomes—The body wall of all vertebrates is supplied by mixed spinal nerves, arranged in regular segmental sequence Each mixed spinal nerve after emergence from the intervertebral foramen divides into posterior and anterior primary rami (Fig 2) The anterior primary ramus ends in its anterior terminal branch near the ventral midline, it gives off a lateral branch which itself divides into anterior and posterior divisions Thus the body wall is supplied in three longitudinal strips the extensor muscles of the vertebral column with the overlying skin are innervated from the posterior primary rami, the lateral part of the body wall is supplied by the lateral branches, and the ventral body wall is supplied by the terminal branches of the anterior primary rami In all vertebrate embryos the limb buds arise from the lateral strip of body wall, supplied by the lateral branches of the anterior primary rami (Fig 1) Miller and Detwiler (1936) showed that limb muscle probably arise from unsegmented somatopleure mesoderm, but the plurisegmental origin, and number of nerves contributing to the limb plexus of the adult, correspond to the location and cranio-caudal length of the embryonic limb bud Murray (1928) indicated that the dermis of the limbs arises likewise from the somatopleure

The lateral branch of each nerve of the limb plexus is projected into the limb to supply it with both sensory and motor fibres The anterior and posterior divisions of the lateral branch supply the anterior and posterior compartments of the limb respectively * Thus we find in the roots of all vertebrate limb plexuses a separation into anterior and posterior

* "Anterior" corresponding to "ventral" or "flexor", and "posterior" to "dorsal" or "extensor"

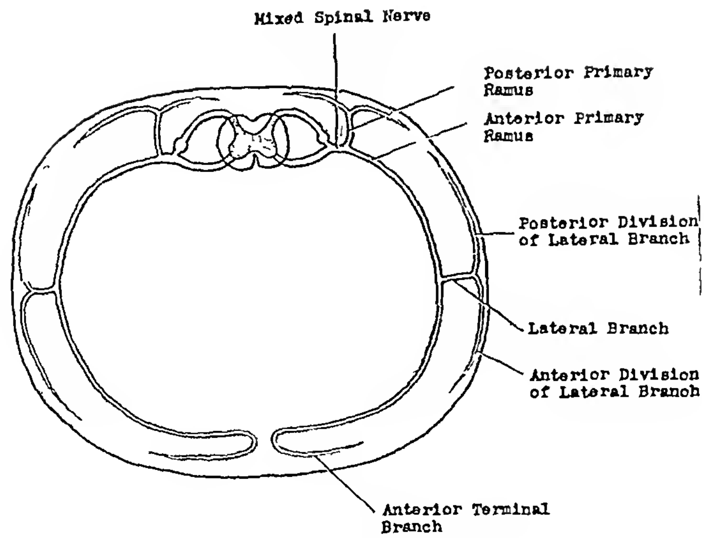

FIG 2

The distribution of a typical mixed spinal nerve

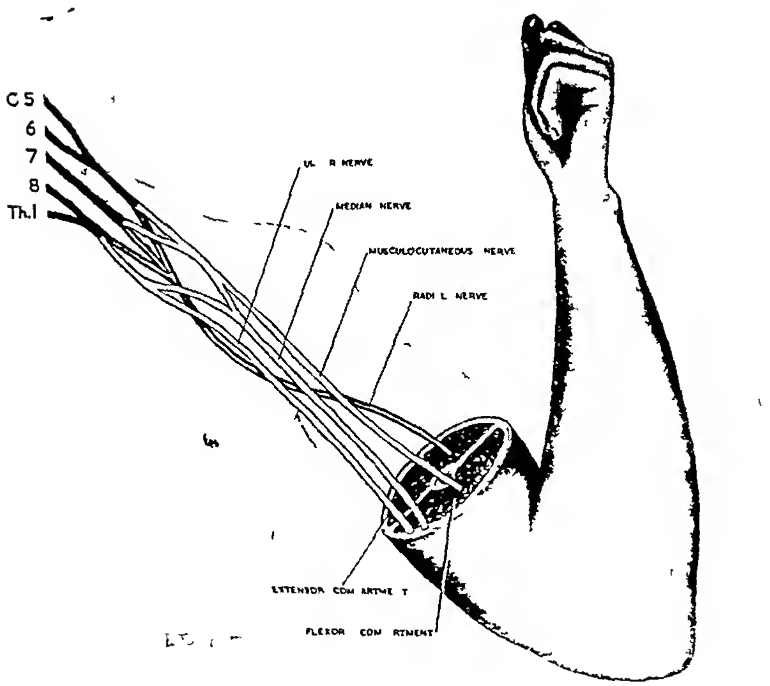

FIG 3

The destination of the anterior and posterior divisions of the trunks of the brachial plexus to the flexor and extensor compartments of the upper limb

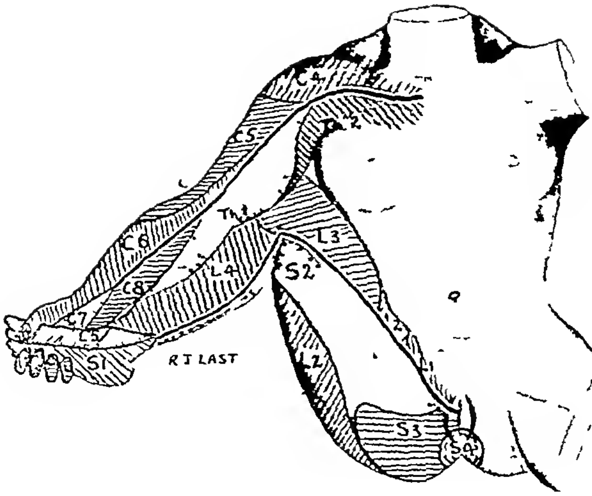

FIG 4

The dermatomes and anterior axial lines (from a *Figure volante* by Rodin—" Iris Messagère des Dieux ')

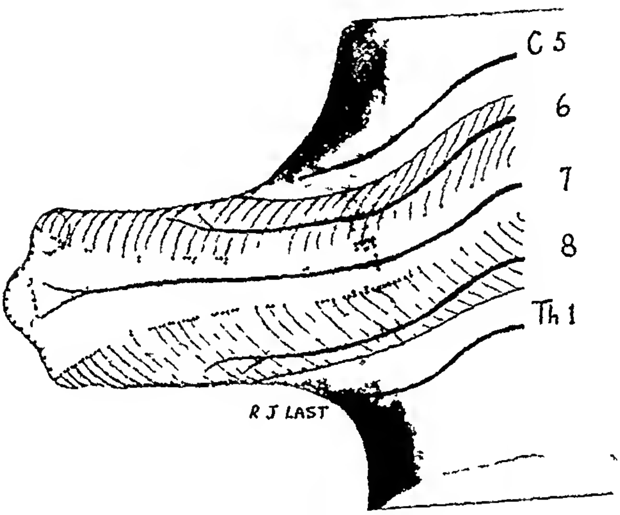

FIG 5

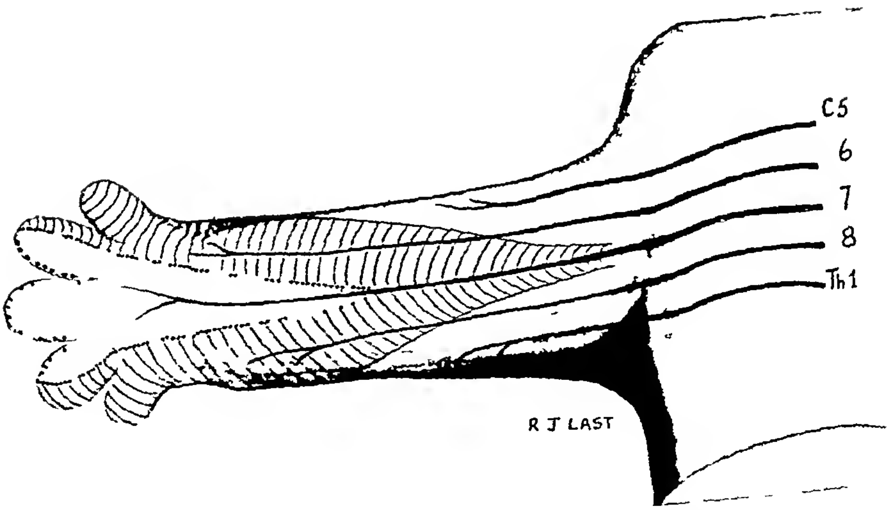

FIG 6

The innervation of the early forelimb bud At an early stage C 7 dermatome is still connected with the trunk (Fig 5) Fig 6 represents a later stage and shows the early formation of the axial line—C 7 dermatome is no longer connected with the trunk

divisions In the case of the brachial plexus the roots first unite into trunks which themselves divide, in the case of the lumbo-sacral plexus the roots divide first and the divisions unite to form the nerves of the lower extremity In each case the anterior and posterior divisions provide separate innervation for the flexor and extensor compartments (Fig 3) Herringham (1886) showed the orderly arrangement by which the skin is supplied on both flexor and extensor surfaces of the limb He stated his " law " under two headings 1) Of two spots on the skin, that which is nearer the pre-axial border tends to be supplied by the higher nerve, 2) of two spots in the pre-axial area, the lower tends to be supplied by the lower nerve and of two spots in the post-axial area the lower tends to be supplied by the higher nerve He continued " Thus, for example, in the arm C 7 will always tend to supply the parts lying nearest the axis of the limb and farthest from the axis of the body, while the sixth, fifth and fourth in the pre-axial area, and the eighth, ninth and tenth (*i e*, C 8, Th 1, Th 2) in the post-axial area, will in that order approach the trunk " Put in another way, Herringham's law stated that progression from pre-axial to post-axial border across the limb encounters the segments in numerical sequence whether the movement is made across the flexor or extensor surfaces of the limb (Fig 4) For example, according to Herringham, movement from the cephalic to the basilic vein crosses C 5, 6, 7, 8 and Th 1 in that order on both the flexor and extensor surfaces of the limb

Axial lines—Sherrington (1893) pointed out that Herringham's law breaks down in the proximal area of a limb On both flexor and extensor surfaces there is a line along which certain dermatomes are missing—a line that represents a gap, across which discontinuous dermatomes meet This *axial line* is possibly produced in the following way The central root of the limb plexus is the first to become attached to the growing tip of the limb bud This is C 7 in the upper limb and L 5 or S 1 in the lower limb The skin is supplied, at first, by this root alone (Fig 5) As the limb bud grows, this area of skin is projected distally and is distracted from the trunk, adjacent dermatomes on the cranial and caudal sides moving in to fill the gap (Fig 6) The line where they meet represents the beginning of an axial line For example, in the upper limb the central segment of the plexus (C 7) is attached to the growing tip of the limb Proximally C 6 and C 8 come into contact at the beginning of the axial line, they in their turn become distracted from the trunk, C 5 and Th 1 coming into contact with each other more proximally still In this way the skin supplied by the five roots is entirely on the limb, which has, indeed, " stolen " some trunk skin cranially (C 4) and caudally (Th 2 and Th 3) as shown in Figure 4

In the upper limb the anterior axial line extends from just above the wrist to the sternal angle of Louis At the level of the second costal cartilage the dermatomes C 4 (supraclavicular nerves) and Th 2 are in contact, the first intercostal nerve has no cutaneous branch and the five missing dermatomes have been distracted outwards into the limb The posterior axial line extends from the vertebra prominens to a point just below the deltoid insertion, the arrangement of dermatomes on the flexor and extensor surfaces of the limb is roughly symmetrical

In the lower limb there is great asymmetry This is due partly to extension and rotation of the adult limb from the foetal position of flexion, and partly to the encroachment of trunk skin supplied by Th 12 and L 1 on to the lower extremity The anterior axial line of the lower limb is mostly on the posterior surface—it is shown in Figure 4 where part of the posterior axial line is also visible on the flexor surface of the thigh All these facts have been well presented by Harris (1943) and are accepted by most investigators It seems easiest to summarise the arrangement of the dermatomes by noting their regular segmental sequence if the axial line is traced down to its extremity along its pre-axial side and back along its post-axial side (Fig 4)

In the upper limb the segments encountered are C 4, 5, 6, 7, 8, Th 1, 2 in that order and in the lower limb L 1, 2, 3, 4, 5, S 1, 2, 3 Adjacent dermatomes overlap considerably, but

there is no overlap across the axial lines The clinical value of the axial lines is very great in the investigation of root lesions or of segmental lesions of the cord For accurate localisation of a single root lesion (as, for example, in disc protrusions) it is helpful to be able to test cutaneous anaesthesia or paraesthesia in regions of missing dermatomes—that i across the axial lines—for here the nerve supply to the skin changes abruptly and there is no confusing overlap of dermatomes such as exists in the rest of the limb and, for that matter in the trunk itself

Another well-known application arises in spinal analgesia A "low spinal" w anaesthetise the skin of the perineum as far forwards as the anterior axial line, the proxim end of which lies at the root of the penis (clitoris) The posterior two-thirds of the scrotu (labium majus) are included, for the dermatome is S 3 To anaesthetise the anterior one-thi of the scrotum (labium majus) it is necessary to go seven segments higher to the level of L 1, there are no less than six missing dermatomes across the proximal end of the anterior axial line They are all out on the limb, covering it with skin (Fig 4)

For accurate maps of the distribution of dermatomes and the site of the axial lines the reader is referred to "Aids to the Investigation of Peripheral Nerve Injuries," a Medical Research Council pamphlet published by H M Stationery Office and reproduced in Cunningham's Text-book of Anatomy (1943) In these maps the overlap of dermatomes is disregarded For a separate map of each dermatome, ignoring the axial lines, see Foerster (1933) modified in Grant's Atlas (1943)

More recently, Keegan and Garrett (1948) reported their findings from a large series of cases, clinical and experimental In several respects they disagreed fundamentally with Sherrington's and Foerster's delineation of the limb dermatomes In particular, according to their evidence the posterior axial lines do not exist the cranial and caudal roots of each plexu spiral around the pre-axial and post-axial borders from behind to meet at the anterior axial line of the limb If their findings are confirmed a fundamental alteration of the accepted dermatome maps will be required On the whole, the dermatomes of Keegan and Garrett are more extensive than those of Sherrington, Head and Foerster Nevertheless, their findi are open to certain criticisms 1) The subjective method of mapping a dermatome by hy algesia, must be open to wide error 2) The lack of overlap of adjacent dermatomes is difficu to accept in face of the almost unanimous opinions of countless observers 3) No mention i made of variability, yet pre-fixation and post-fixation of the plexuses are known to be common 4) Their claim that an isolated nerve root is affected in their cases of disc protrusions or injected medical students is not convincing, there may well have been some involvement of adjacent nerve roots Those interested should consult the article of Keegan and Garrett (1948)

SEGMENTAL SUPPLY OF LIMB MUSCLES

The position of the axial lines and dermatomes is well known and easily remembered but the existence of an orderly sequence in the motor innervation of the limb musculature is not so widely appreciated In order to learn the segmental origin of the motor nerve to every limb muscle it has hitherto been necessary to memorise long tables which, in themselve are meaningless Similarly the muscular distribution of any spinal root of a limb plexus h to be memorised The lack of correspondence between overlying dermatomes and underlyin myotomes has often proved a source of confusion, or at least perplexity, to the student to whom the comparatively orderly arrangement of the dermatomes seems to cover a bewilderi chaos of myotomes But if the fundamental manner in which *joint movements are segment innervated* is appreciated the whole of the complex subject of muscle segmentation becom rational and can be mastered in a matter of minutes

Rules of segmental innervation—In general it may be said (though this is less true of th upper limb than the lower) that any movement of a joint is innervated by two adjoin segments The four segments concerned in a movement and its opposite are in numer segments

sequence, they control all movements possible in the joint For example, the spinal centre for the hip joint includes lumbar segments 2, 3, 4, 5, of which 2 and 3 control flexion, medial rotation and adduction, while 4 and 5 control the opposite movements, namely, extension, lateral rotation and abduction The second rule is that in passing distally one joint into the limb the four segments comprising the joint innervation centre are, *en bloc*, one segment lower in the cord Thus the centre for the knee is 3, 4, 5, 1 (lumbar and sacral respectively) and it follows that for the ankle, one joint lower in the limb, the centre will be one segment lower, namely, 4, 5, 1, 2

Lower limb—The spinal centres controlling the hip, knee and ankle consist each of four segments, namely hip 2, 3–4, 5, knee 3, 4–5, 1, and ankle 4, 5–1, 2 To dissociate the centres into flexor and extensor components, start by contracting the *anterior* muscles first These are innervated from the upper two segments in the case of each joint (Table I)

TABLE I

SEGMENTAL INNERVATION OF JOINTS OF THE LOWER LIMB

Hip		Knee		Ankle		Foot	
Flex	2						
	3	Extend	3				
Extend	4		4	Dorsiflex	4		
	5	Flex	5		5		
			1	Plantarflex	1	Intrinsic muscles	1
					2		2
							3

These and other joint movements to be described can be performed (if only mentally) while saying the numbers and in this way the whole system can be memorised readily, as in learning the movements of an exercise (Fig 7) A knowledge of the primary action of any muscle is all that is now required to give its nerve supply The following are examples

Psoas and iliacus (flex hip)	2 3
Vastus intermedius (extends knee)	3 4
Soleus (flexes ankle)	1 2

The above are simple antero-posterior movements of the joints of the lower limb The segmental innervation of inversion and eversion of the foot is shown in Table II

TABLE II

SEGMENTAL INNERVATION OF TARSAL MOVEMENTS

Invert foot	4
Evert foot	5
	1

This gives an indication of the innervation of the anterior and posterior tibial and the peroneal muscles It is important to remember this, because tibialis posterior is innervated by L 4, not by S 1 and S 2 like the other foot flexing muscles among which it lies It should also be noted that all the movements at the hip are innervated by the same four segments that control flexion and extension (Table III)

TABLE III

SEGMENTAL INNERVATION OF LATERAL AND ROTATIONAL MOVEMENT AT THE HIP

Adduction and medial rotation (*cf* flexion)	2
	3
Abduction and lateral rotation (*cf* extension)	4
	5

From this analysis it will be seen that, with the exception of inversion of the foot, each movement of a joint is controlled from two spinal segments, and the opposite movement by the two segments next in numerical sequence If these movements with their corresponding numbers are memorised it becomes a simple matter not only to state the segmental value of a given muscle but also mentally to work out the essential muscular distribution of any segment

Upper limb—In the case of the upper limb the rule that each joint movement is controlled through two contiguous spinal segments does not hold quite so universally as in the case of the lower limb In three cases the essential segment is a single one But the rule that joints farther down the limb are controlled by spinal centres lower down in the cord still holds The segments controlling the joints of the upper limb are shown in their simplest form in Table IV

TABLE IV

SEGMENTAL INNERVATION OF JOINTS OF THE UPPER LIMB

Shoulder		Elbow				Wrist		Hand
Abduct								
externally rotate	5	Flex	5					
Adduct			6	Pronate	6			
internally rotate	6			Supinate	6	Flex	6	
	7	Extend	7				7	
	8		8			Extend	8	Intrinsic muscles Th 1

It is to be noted that flexion and extension of the shoulder are not included, pectoralis major, latissimus dorsi and deltoid are used in these movements, and they are already covered in the above analysis The segments involved are 5, 6, 7, 8 (5 for deltoid and 6, 7, 8 for pectoralis major and latissimus dorsi) The following examples indicate the application of the formula

Pectoralis major (adducts shoulder)	6 7 8
Latissimus dorsi (adducts shoulder)	6, 7 8
Deltoid (abducts shoulder)	5
Subscapularis (internally rotates shoulder)	6 7
Brachioradialis (flexes elbow)	5 6

It may be objected that in the first two examples the list of segments quoted is not complete, as the muscles receive fibres from all five roots of the brachial plexus, or it may be pointed out that the deltoid receives C 5 and 6, not merely C 5 as given here Although muscles may receive fibres from several roots it is usually true that not all these roots are of equal significance The constitution of the phrenic nerve illustrates the point There is no doubt that C 3, 4 and 5 form the phrenic nerve, but the essential segment is C 4, for without it the diaphragm will not function Therefore, for practical purposes the segmental innervation of the diaphragm is C 4, and it is indeed debatable whether it is not poor teaching to include C 3 and 5, in case the student should give them an emphasis equal to C 4 The scheme outlined here is intended to indicate the *essential* segments with sufficient accuracy for clinical purposes For the clinician and the medical student the scheme provides a simple method of remembering the segmental supply of any limb muscle and the muscular distribution of any spinal segment

Detailed analysis of segmentation in the gluteal region and forearm—For those who wish to have a more accurate conception of segmental innervation of muscles the gluteal region and forearm may be considered further

The muscles of the gluteal region—In the simple scheme the innervation of extension, abduction and lateral rotation of the hip is given as L 4, 5 These are the essential segments, but others contribute Fortunately there is an easy scheme of memorising the more detailed arrangement it is to remember the superior gluteal nerve as 4, 5, 1 and the inferior gluteal as one segment

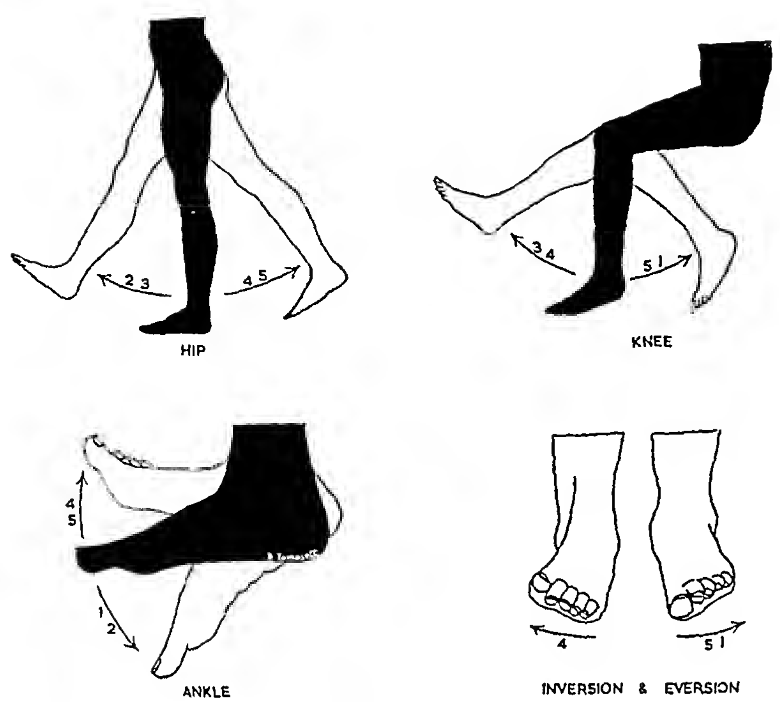

FIG 7

The segmental innervation of the movements of the lower limb

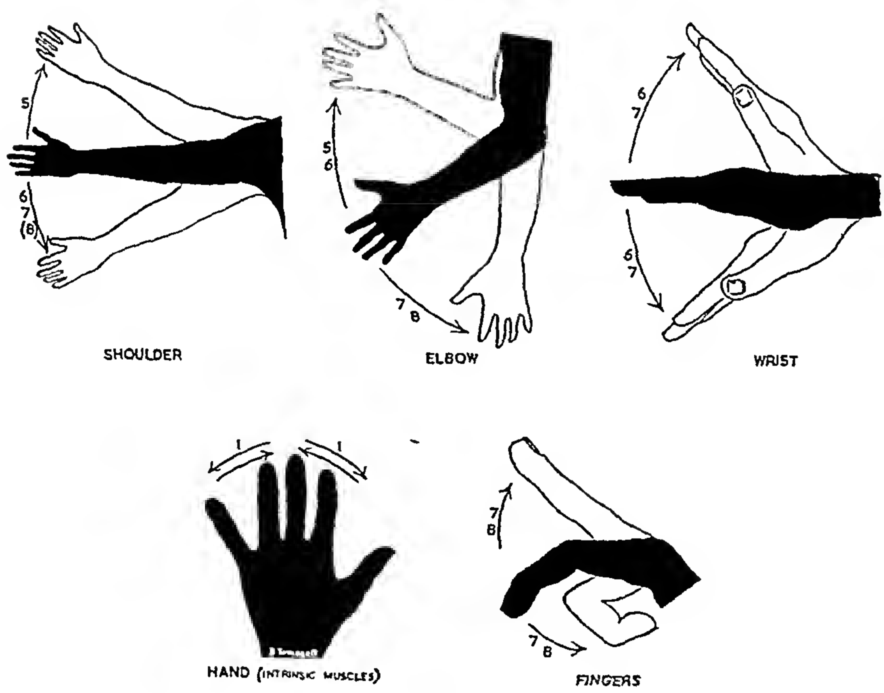

FIG 8

The segmental innervation of the movements of the upper limb

lower, namely, 5, 1, 2 The same three segments are contained in the nerve to quadratus femoris and the nerve to obturator internus respectively (note that the higher group of segments supplies the apparently lower muscles) (Table V)

TABLE V

SEGMENTAL INNERVATION OF THE GLUTEAL MUSCLES

Nerve to quadratus femoris and inferior gemellus	4 5, 1	Superior gluteal nerve (gluteus medius gluteus minimus tensor fasciae femoris)
Nerve to obturator internus and superior gemellus	5 1 2	Inferior gluteal nerve (gluteus maximus)

All the muscles of the buttock fall into one or other of these groups except piriformis which is not a true lower limb muscle but part of the prevertebral rectus that has migrated downwards to gain attachment to the lower limb and still retains its segmental innervation from separate spinal nerves (S 1,2) The lower group, 5, 1, 2, supplies gluteus maximus (inferior gluteal nerve) and obturator internus with its superior gemellus (nerve to obturator internus), all the remaining muscles of the buttock are supplied by 4, 5, 1

The muscles of the forearm—In the simple scheme the innervation of all the flexor muscles in the forearm is given as C 6, 7, and of all the extensors, C 8 It is probably more important to enlarge this formula than is the case with the muscles of the buttock The second rule of segmental innervation holds in the case of the forearm, namely, that the more distal joints in the limbs are under control of more caudally placed centres It is best to consider them from above downwards, remembering the elbow as 5, 6–7, 8 (Fig 8) The detailed segmental innervation is shown in Table VI

TABLE VI

SEGMENTAL INNERVATION OF THE MUSCLES OF THE FOREARM

Wrist—Flex	6 7
Extend	6, 7
Fingers and thumb—Flex	7, 8
Extend	7 8
(one joint lower one segment lower)	
Hand intrinsic muscles	Th 1
(one segment lower)	

It is interesting to note the innervation of the wrist flexors Flexor carpi radialis is innervated by C 6, 7, and this is indicated in the above formula, but it does not appear that flexor carpi ulnaris fits into this scheme, innervated as it is from the ulnar nerve The medial cord, from which the ulnar nerve is derived, contains C 8 and Th 1 fibres only But Walsh (1877) has described a contribution from the lateral cord to the ulnar nerve in the axilla in over 90 per cent of 290 dissections of the brachial plexus, and in half the remainder he found a communication from C 7 to the medial cord and so to the ulnar nerve Wilfred Harris (1904) in thirty dissections made similar observations, the lateral head of the ulnar nerve was present in twenty-six dissections, and he adds the significant observation that clinical evidence suggests that flexor carpi ulnaris is supplied with C 7 fibres A frequency of the order found by Walsh and Harris makes the delicate lateral head of the ulnar nerve almost as constant a constituent of the brachial plexus as any other nerve, in spite of its absence from current text-book descriptions It is the writer's suggestion that the reason for the existence of the lateral head of the ulnar nerve is that flexion of the wrist is under control of the wrist centre at C 6, 7, and that the efferent fibres from this centre must reach flexor carpi ulnaris and are forced to take this route The flexor carpi ulnaris is, in fact, innervated by the fibres from the seventh cervical segment

Discussion—Among the earliest investigations into the segmental supply of limb muscles were those of Ferrier and Yeo (1881), who reported the multi-jointed movements obtained by stimulation of single spinal nerves and determined most of the muscles that contract They stated "It is evident that the cervical and lumbar enlargements of the spinal cord are centres of highly co-ordinated muscular combinations" It has been said that in no sense can the dermatomes and myotomes of the limbs be said to correspond There is one minor point of apparent resemblance that can be very misleading in a few situations a muscle on the pre-axial border has a higher segmental supply than one on the post-axial border (for example, brachio-radialis and the ulnar flexor and extensor of the wrist, the anterior and posterior tibials and the peronei) Such an arrangement is entirely fortuitous and has no place in the underlying plan of limb segmentation Nevertheless, it was enough to deceive Herringham (1886) who stated "The superficial thumb muscles are supplied by C 6 or C 7, never from C 8 or Th 1, the little finger muscles are supplied by C 8 as are the deep muscles of the hand There is no Th 1 in the hand" Sherrington (1892) denied this and showed that, on the contrary, the intrinsic muscles of the hand are supplied by Th 1 only In the Rhesus monkey he showed, too, that in the muscles of the hand there is no intra-segmental variation in Th 1 segment from the pre-axial to the post-axial side of the hand Furthermore he pointed out that in the case of the gastrocnemius the lateral head has a higher segmental innervation than the pre-axial medial head—thus putting Herringham's hypothesis out of court Herringham's conception of higher pre-axial supply was brilliantly true of dermatomes, false of myotomes His conclusions on root distribution were made by direct dissection in man Sherrington's conclusions were made by stimulation of single separate spinal nerves in Rhesus and the cat, a procedure which, by the nature of the arrangement of the spinal centres, could never produce the normal regular joint movements (Fig 9) The author agrees with Wilfred Harris (1904) that "neither of these methods is more than approximately correct when its results are directly applied to the motor distribution of the human plexus" It is an example which illustrates the limitations of the analytical method of experimental investigation It is, in the writer's opinion, only by the synthetic method of approach that the truth can be arrived at in this case The writer has attempted to reproduce joint movements in the cat by stimulation of the anterior grey columns, but with very equivocal results, as may be expected It is not possible to confine the stimulus to one single joint centre It is by clinical observation in man that the segmental motor distribution can be precisely determined, once done, the extent of the spinal centres can be inferred from this evidence

Much more accurate information is now available than was possessed by either Herringham or Sherrington, though it should be stated that the final word about the segmental innervation of the limb muscles has by no means been written Many details of distribution of segmental fibres are still unknown In particular, the destination of S 3 in the medial popliteal nerve is very uncertain, the author feels that there is significance in Guttmann's (1947) view, based on clinical evidence, that it supplies the intrinsic muscles of the sole of the foot, such a distribution would fit in with the concept that the most peripheral joints in a limb are controlled by the most caudally placed spinal centres In this connection also Sherrington's work is of interest In the stately circumlocution of a more spacious age he wrote (1892) "In view of my own experiments the probability amounts in my own thinking almost to certainty that in man the lower limit of the motor outflow to the intrinsic muscles of the foot does often, though not always, extend into the third sacral root"

An appreciation of the principles outlined above shows how orderly is the arrangement in which the muscle segments are distributed in the limbs in regular sequence for consecutive joint movements The whole system of myotomes and their innervation becomes clear Area 4 in the prerolandic cortex controls not muscles but joint movements This control is exercised through spinal centres composed of segments that are arranged in orderly sequence from above downwards, generally in groups of four segments for each joint It is probable

that the subcortical control of common movements in lower animals is in large measure spinal, and that it exists in such spinal centres as have been described above in man Sherrington (1892) and Bruce (1901) described the existence of such cell aggregates in the adult spinal cord, and the latter's atlas gives a description of their situation and the number of anterior horn cells in each Sherrington described three groups of cells in the anterior horn, a medial an antero-lateral and a postero-lateral He was of opinion, correctly, that the medial group innervates the muscles of the body wall, the lateral groups the muscles of the limbs At a meeting of the Physiological Society in 1892 he showed the spinal cord of an adult cat In C 8 the postero-lateral group of anterior horn cells was much reduced on one side —the side from which the forefoot had been amputated when the animal was less than a month old His conclusion that the motor cells of the limb muscles lie in the lateral regions of the anterior horns has since received ample confirmation, both clinical and experimental Romanes (1941 etc) has shown that spinal centres exist as anatomical entities in foetal man, rabbit and rat, and that the more caudally placed centres are situated more posteriorly in the lateral part of the anterior horn It seems inconceivable that the centres so precisely described by Romanes can be anything but the spinal centres for joint movements inferred to exist by the author, and a hypothetical reconstruction of the joint centres can be made with some confidence Such a reconstruction of the lower limb centres in man is shown in Fig 9 A reconstruction for the upper limb centres in the cervical enlargement would be similar, following the formulae indicated in Tables IV and VI The boundaries of the joint centres are not precise and sharply demarcated, but shade off as do the boundaries of the cortical centres in Area 4 The main central core of the areas is indicated in the formulae, the centre itself can sometimes be taken as extending a further segment above or below that stated—though not beyond the limits of the plexus itself

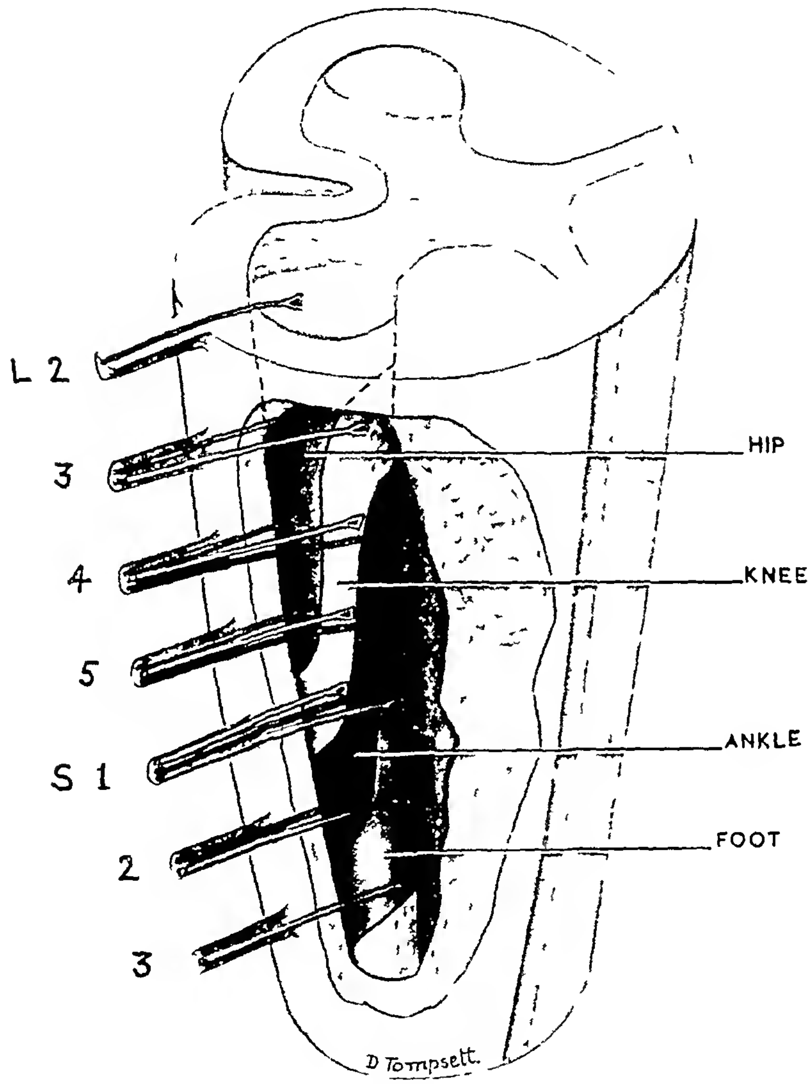

FIG 9

The spinal centres for the lower limb in man

The clinical importance of the precise location in the cord of the spinal centres is less than that of the cortical centres, because a lesion confined exclusively to a single joint area

is unlikely to occur in the cord But the existence of such centres is of great academic interest, and their precise levels can be so easily remembered that the scheme can be made to serve virtually as a mnemonic to place the segmental supply of any muscle The author has taught the scheme to several hundred postgraduate students, to whom it has given great satisfaction Many examples of its application have been recalled by these doctors from their own clinical experience Perhaps the most striking example was the case of a Jamaican member of a class, whose smile of comprehension and satisfaction became wider and wider as the lecture proceeded At its conclusion the case he presented was his own Anterior poliomyelitis at the age of eighteen months had left him with gluteal weakness, quadriceps weakness with absent knee jerk, and inability to invert the foot but without foot drop He had never understood the anatomy of his lesion until that moment—it was a pure L 4 paralysis, as reference to the Tables for the lower limb (Tables I and II) will show

Pre- and post-fixation—The above figures refer to the segments in normally placed limb plexuses In cases of pre- and post-fixation the appropriate number of segments must be subtracted or added The incidence of pre- and post-fixation is high, exact figures are not known But although a segment to a limb may vary with regard to the vertebral column, the segments always maintain their relative positions to each other, a fact which was known to Herringham in 1886

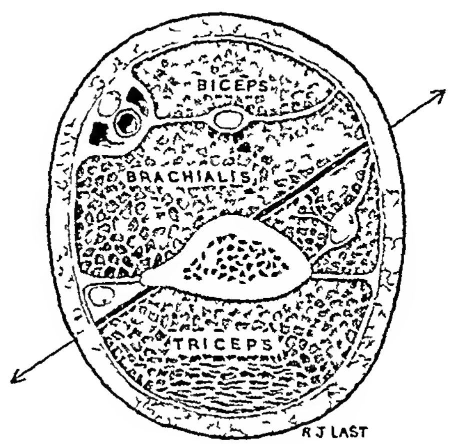

FIG 10

Cross-section of the arm above the elbow The arrow indicates the site of the foetal intermuscular septum between flexor and extensor compartments

MUSCLES WITH A DOUBLE NERVE SUPPLY

Each component root of a limb plexus divides into an anterior and posterior division for the innervation of the flexor and extensor compartments respectively In the brachial plexus the division takes place after the formation of the trunks, while in the simpler lumbo-sacral plexus it takes place before the formation of the branches The more precisely acting flexors demand a richer innervation than the coarser extensor muscles, consequently we find that the most caudal root of a plexus (Th 1, S 3) is distributed, as far as its motor fibres are concerned, entirely to the flexor compartment of the limb

With these facts in mind it is easy to understand that such a muscle as flexor digitorum profundus with its accompanying lumbricals can have a double nerve supply, from the ulnar and median nerves, for each of these is a nerve of the flexor compartment of the upper limb, derived originally from the anterior divisions of the trunks It is more difficult to understand the branch to brachialis from the radial (musculospiral) nerve, for the radial nerve is the nerve of the extensor compartment while brachialis is a flexor muscle The explanation is that the portion of brachialis innervated by the radial nerve developed in the extensor compartment of the foetal limb Subsequent alteration in position of the septum between the flexor and extensor compartments has included this part of brachialis in the flexor compartment, where it fuses with that part innervated by the musculocutaneous nerve (Fig 10) Also included in the flexor compartment are the brachio-radialis muscle and that part of the radial nerve which runs above and anterior to the elbow joint A similar extent of the ulnar nerve, a nerve of the flexor compartment, is contained in the extensor compartment The lateral and medial intermuscular septa of the adult arm do not represent the foetal division between flexor and extensor compartments

In the case of the hamstrings, all are supplied by the medial popliteal moiety of the sciatic nerve (the nerve of the flexor compartment) except the short head of the biceps This although a flexor muscle, is supplied by the lateral popliteal component of the sciatic nerve which is the nerve of the extensor compartment of the leg The reason is that the short head of the biceps was developed in the extensor compartment and only later migrated into the flexor compartment Pectineus affords another example An adductor of the thigh, it is always developed in the extensor compartment and is supplied usually by the femoral nerve the nerve of the extensor compartment, but in one out of three individuals it derives its supply also from an accessory obturator nerve The obturator nerve itself is a nerve of the flexor compartment But the accessory obturator nerve is misnamed, it arises from *posterior* divisions of the lumbar nerves (2, 3) and notwithstanding the fact that it emerges on the medial side of psoas should rightly be called the accessory femoral Like the femoral it emerges on the cephalic side of the pubic bone, the true obturator nerve emerges on the caudal side of that bone In some cases pectineus receives fibres from the true obturator nerve, in such cases that part of the muscle innervated from the obturator will have developed in the flexor (obturator) compartment The muscle lies at the pre-axial border of the limb and, like brachialis, is formed by fusion of flexor and extensor flesh

In short, the nerve supply of all muscles is a certain guide to their embryological development

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Percivall Pott
1714-1788

Percivall Pott

Percivall Pott is perhaps the best-known English surgeon of the pre-antiseptic era His fame in the eighteenth century has persisted and been maintained by clear descriptions of the injury and diseases of bone that are associated with his name In him is to be seen the beginning of an attitude untrammelled by irrational obedience to the dictates and practices of the early fathers of medicine He had great influence on the development of English surgery

He was born on January 6, 1714, in Threadneedle Street, London The house was subsequently pulled down and on its site an extension of the Bank of England was built His father, a descendant of an old Cheshire family, died when he was only three years old, leaving a wife and child in somewhat straitened circumstances The mother, anxious about the boy's education, received help from her relative, Dr Wilcox, Bishop of Rochester, and Percivall was thus sent to a school at Darenth in Kent Here he made good progress in the classics and it was thought that he might become a candidate for holy orders, but he was attracted to medicine

To secure entrance to the medical profession, apprenticeship to a regular practitioner was then necessary and most pupils became attached to an apothecary in private practice Few probationerships were available at hospitals but young Pott was fortunate, for in his sixteenth year he obtained a seven years' apprenticeship to Edward Nourse, assistant surgeon to St Bartholomew's Hospital, paying two hundred guineas for his indentures Nourse lectured in anatomy and surgery at Barber-Surgeons' Hall and at London House in Aldersgate Street For these lectures Pott dissected demonstration specimens and laid the foundation of the anatomical knowledge which later gave him so great an advantage over his contemporaries

After apprenticeship to Edward Nourse, on "September 7, 1736, Percivall Pott was admitted to the Freedom of the Company (of the Barber-Surgeons) by service, upon the testimony of his master and was sworn" Later the same day "the said Mr Percivall Pott was examined touching his skill in surgery in order to have the Great Diploma His answers were approved, and he was ordered a Diploma under the seal of the Company and the hands of the Governors testifying his skill and impowering him to practise" The Great Diploma was a rare award and was granted only after very thorough examination, in some ways it corresponded to the present F R C S

Pott took a house in Fenchurch Street into which he moved with his mother and her daughter by her first marriage A few years later he moved to Bow Lane and whilst practising there took the livery of the Barber-Surgeons' Company and paid the usual fine of £10 In 1745 he was elected assistant surgeon to St Bartholomew's Hospital, becoming full surgeon four years later

In the year that Pott was appointed to the staff of St Bartholomew's, the Barber-Surgeons' Company was dissolved by Act of Parliament after a partnership of two hundred years A few weeks after separating the surgeons met together at Stationers' Hall as "The Master, Governors and Commonality of the Art and Science of Surgery" which body afterwards became known as the Corporation of Surgeons In 1751 they settled in their own quarters in the Old Bailey Pott took a very active part in the affairs of the new Corporation and on July 5, 1753, its Court of Assistants elected him and William Hunter as the first Masters (or Lecturers) of Anatomy Later Pott was appointed to other offices and in 1765 was elected Master (or Governor) of the Corporation

When Pott began his work as hospital surgeon there was little organised teaching of medical students in London Samuel Sharp of Guy's gave a course of evening lectures on anatomy, surgical operations and bandaging to a Society of Naval Surgeons which met at

Covent Garden, and Edward Nourse gave occasional lectures on surgical principles at St Bartholomew's Percivall Pott was the first to introduce regular teaching of clinical surgery at the bed-side He spoke of cures, mistakes and experience of other patients with similar disorders and such instruction drew many students around him, some of whom included John Hunter, Abernethy, Blicke and Earle He also gave lectures in his own house in Watling Street, to which he had removed from Bow Lane, and the attractive manner of his delivery was testified by Sir William Blizzard when he said "It was difficult to give an idea of the elegance of his language, the animation of his manner or the perceptive force or effect of his truths and his doctrines"

At the time that Pott was elected to the staff of St Bartholomew's Hospital he wrote a paper—"An Account of Tumours which rendered the Bones Soft"—which was published in the Philosophical Transactions After that contribution he was silent for twelve years, but at the age of forty-three an event occurred which induced him to become a constant writer in surgery whereby he gained world-wide fame It was in 1756 while riding in what is now known as the Old Kent Road that an accident befell him Sir James Earle, his son-in-law and biographer, relates that

> He was thrown from his horse and suffered a compound fracture of the leg the bone being forced through the integuments Conscious of the dangers attendant on fractures of this nature and thoroughly aware how much they may be increased by rough treatment or improper position he would not suffer himself to be moved until he had made the necessary dispositions He sent to Westminster, then the nearest place for two Chairmen to bring their poles and patiently lay on the cold pavement it being the middle of January till they arrived In this situation he purchased a door to which he made them nail their poles When all was ready he caused himself to be laid on it and was carried through Southwark, over London bridge to Watling-Street near St Paul's where he had lived for some time—a tremendous distance in such a state! I cannot forbear remarking that on such occasions a coach is too frequently employed the jolting motion of which with the unavoidable awkwardness of position and the difficulty of getting in and out cause a great and often a fatal aggravation of the mischief At a consultation of surgeons the case was thought so desperate as to require immediate amputation Mr Pott, convinced that no one could be a proper judge in his own case submitted to their opinion, and the instruments were actually got ready when Mr Nourse who had been prevented from coming sooner fortunately entered the room After examining the limb he conceived there was a possibility of preserving it an attempt to save it was acquiesced in and succeeded This case which Mr Pott sometimes referred to was a strong instance of the great advantage of preventing the insinuation of air into the wound of a compound fracture and probably would not have ended so happily if the bone had not made its exit or external opening at a distance from the fracture so that when it was returned into the proper place, a sort of valve was formed which excluded air Thus no bad symptom ensued, but the wound healed in some measure by the first intention

Sir D'Arcy Power thought that "the accident which Pott sustained was an open fracture of the tibia—spiral or very oblique—and that the nib-shaped end of the upper fragment penetrated the skin" Bearing in mind the gloomy fate of a compound fracture up to the mid-Victorian era, Pott himself contributed greatly to the preservation of his limb and the good healing of his fracture by his foresight in safeguarding the leg from the moment of accident until he reached his home

Up to the time of his accident Pott had recorded his experiences and investigations in the manuscripts of his lectures but had published none of them He took advantage of the leisure imposed by convalescence in preparing for publication and, once started as a writer, continued writing for over twenty years His first work—"A Treatise on Ruptures"—appeared in 1756, followed by several others on diseases of the testicle, head injuries, curvature of the spine with lower limb palsy, fractures and dislocations

Pott's Fracture—One of the important contributions to surgery by Pott was his monograph entitled "Some few General Remarks on Fractures and Dislocations" published in 17[illegible] He opposed the existing treatment by continuous instrumental traction which was irksome and fatiguing He asserted that a fracture could be best reduced and correction maintained

by keeping the limb in such a posture that the muscles were continually relaxed. This teaching had a far-reaching effect, for Pott's method of treating fractures was generally adopted in England and it prevailed for several generations. In this monograph he also described the fracture-dislocation of the ankle that now bears his name, with an illustration of the resulting valgoid displacement of the foot and a drawing of the skeletal injuries responsible for it. His description is quite impersonal and he makes no mention of the fracture that he himself sustained. In consequence there has been some misapprehension as to the nature of Pott's accident. His classical description of the ankle fracture-dislocation, and his reticence about his own fracture of the tibia at a higher level, have misled many to believe that in describing the ankle injury he was speaking of something within his own intimate experience. This misconception has helped to fasten his name to the fracture-dislocation which he portrays in these words

When by leaping or jumping the fibula breaks in the weak part already mentioned, that is within two or three inches of its lower extremity. When this happens, the inferior fractured end of the fibula falls inward toward the tibia, that extremity of the bone which forms the outer ancle is turned somewhat outward and upward and the tibia having lost its proper support and not being of itself capable of steadily preserving its true perpendicular bearing, is forced off from the astragalus inwards by which means the weak bursal or common ligament of the joint is violently stretched, if not torn, and the strong ones which fasten the tibia to the astragalus and os calcis are always lacerated, thus producing at the same time a perfect fracture and a partial dislocation, to which is sometimes added a wound in the integument, made by the bone at the inner ancle. When this accident is accompanied as it sometimes is by a wound of the integuments of the inner ancle and that made by the protrusion of the bone, it not infrequently ends in a fatal gangrene unless prevented by timely amputation though I have several times seen it do very well without. But in its most simple state, unaccompanied with any wound, it is extremely troublesome to put to rights, still more so to keep it in order and unless managed with address and skill, is very frequently productive both of lameness and deformity ever afterward.

Pott's Disease—The best known of Pott's contributions to surgery was his treatise entitled "Remarks on that kind of Palsy of the lower limbs which is frequently found to accompany A Curvature of the Spine and is supposed to be caused by it." It was published in 1779 and was translated into French and Dutch, the disease which it described became known on the continent as "La maladie du Pott." This monograph reveals his ability as a clinical observer and the lucidity of his diction. He painted these patients with their symptoms and signs with so sure a touch that we can add nothing to the picture. He differentiated between flaccid and spastic paralysis and noted that spasticity was the invariable rule of spinal cord pressure in spinal caries. He said

The disease of which I mean to speak is generally called a palsy, as it consists in a total or partial abolition of the power of using, and sometimes of even moving the lower limbs, in consequence, as is generally supposed, of a curvature of some part of the spine. To this distemper both sexes and all ages are equally liable. Until the curvature of the spine has been discovered, it generally passes for a nervous complaint. I have in compliance with custom called the disease a palsy, yet there are some essential circumstances in which this affection differs from a common nervous palsy. The legs and thighs are rendered unfit for all the purposes of locomotion and do also lose much of their sensibility, but they have neither the flabby feel which a truly paralytick limb has, nor have they that seeming looseness at the joints, nor that total incapacity of resistance which allows the latter to be twisted in almost all directions, on the contrary the joints have frequently a considerable degree of stiffness, particularly the ancles, by which stiffness the feet of children are generally pointed downward, and they are prevented from setting them flat upon the ground.

A second essay was published in 1782 in which Pott dealt mainly with the morbid anatomy of disease of the spine, accompanied by engravings illustrating the changes that occurred in the vertebrae. He concluded that the disorder had its origin elsewhere in the body, the disease was scrophula, and was capable of revealing itself in a variety of organs. To give it a modern terminology, tuberculosis is an infective disease with local manifestations. In concluding his essay with a summary of the morbid anatomy he said

"This morbid affection shews itself in a variety of forms, but although its appearances be various yet they are always such as determine the true nature of the distemper. Sometimes it appears in a thickened state of the ligaments connecting the vertebrae together, without any apparent affection of the bone. Sometimes in the form of a distempered state of the intervertebral substances, called cartilages. Sometimes in that of diseased glands either in a merely indurated and enlarged state or what is more frequent in that of a partial suppuration. Sometimes it is found in the form of bags or cysts, containing a quantity of stuff of a unequal consistence, partly purulent, partly sanious and partly a curd-like kind of substance and not unfrequently entirely of the last. Sometimes under these bags or cysts, even while they remain whole, the subjacent bones are found to be distempered that is deprived of periosteum, and tending to become carious. Sometimes these collections erode the containing membranes and make their way downward by the side of the psoas muscle, towards the groin or by the side of the pelvis behind the great trochanter, or in some cases to the outside of the upper part of the thigh. That the disease which produces these effects on the spine, and the parts in its vicinity is what is in general called the scrophula; that is, that same kind of indisposition as occasions the thick upper lip, the tedious obstinate ophthalmy, the indurated glands under the chin, and in the neck, the obstructed mesentery the hard dry cough, the glairy swellings of the wrist and ancles the thickened ligaments of the joints the enlargement and caries of the bones."

The treatment of spinal disease had been directed towards the straightening of the kyphosis and was attempted by means of "steel stays, the swing, the screw chair and other pieces of machinery." Pott had observed that no permanent good purpose had been served by these procedures and he deliberately made no attempt to correct the deformity. This was a new departure in treatment and was the first sign of understanding of the natural process of cure by osseous fusion through vertebral collapse. But he was persuaded, partly by the inspiration of Hippocratic teaching, to form an artificial sinus by applying caustic to the skin on each side of the gibbus in the belief that a prolonged flow of exudate had curative value. He seemed confirmed in his view by the frequent relief of paralysis in patients submitted to this operation. It was not performed with the object of draining an abscess, and indeed there seldom is any superficial abscess in Pott's paraplegia. But he did cure the patients in another way. The artificial sinus imposed recumbency, and in consequence of prolonged rest the paralysis disappeared. Pott, like many of his successors failed to realise the decisive importance of rest. It was not until nearly a century later that the value of rest in joint tuberculosis was formulated by Hilton and Hugh Owen Thomas.

Pott's Puffy Tumour—Pott took considerable interest in head injuries. In 1760 he published a monograph entitled "Observations on the Nature and Consequences of Wounds and Contusions of the Head, Fractures of the Skull, Concussions of the Brain, etc." This was followed in 1768 by another monograph, and two further editions of the work appeared later. These productions were prepared carefully and bore evidence of extensive reading of Latin and French writings on the subject. He did much to simplify trephining of the skull and advanced the knowledge of the morbid anatomy of cerebral injury. His publications included abundant case histories which are interesting apart from their main purpose, his delightful narrative touches upon the occupations, social habits and customs of ordinary people in the eighteenth century. The particular scalp swelling or puffy tumour that he described is referred to in this paragraph.

"If the symptoms of pressure, such as stupidity, loss of sense, voluntary motion etc. appear some few days after the head has suffered injury from external mischief they do most probably imply an effusion of a fluid somewhere this effusion may be in the substance of the brain in its ventricles between its membranes, or on the surface of the dura mater and which of these is the real situation of such extravasation is a matter of great uncertainty, none of them being attended with any peculiar mark or sign that can be depended upon as pointing it out precisely but the inflammation of the dura mater and the formation of matter between it and the skull, in consequence of contusion, is generally indicated and preceded by one which I have hardly ever known to fail, I mean a puffy, circumscribed indolent tumour of the scalp and a spontaneous separation of the pericranium from the skull under such tumour. These appearances therefore following a smart blow on the head, and attended with languor pain restlessness watching quick pulse headache and slight irregular shiverings do almost infallibly indicate an inflamed dura mater and pus, either forming or formed between it and the cranium."

Pott's contributions to the knowledge of head injuries did much to establish him as one of the leading surgeons of his day But apart from these familiar eponymous disorders, a mass of scientific knowledge deriving from Pott has long since been incorporated in surgical literature One instance is chimney-sweep's cancer which he was the first to describe, he was the first to point out the carcinogenic properties of soot on man The experimental verification of Pott's observations on the production of cancer in mice by soot irritation was accomplished by Passey in 1920 Moved by the misery of the chimney-boys he drew the attention of profession and public to the evil nature of their occupation

"The fate of these people seems singularly hard, in their early infancy, they are most frequently treated with great brutality and almost starved with cold and hunger, they are thrust up narrow and sometimes hot chimneys where they are bruised burned and almost suffocated, and even when they get to puberty become peculiarly liable to a most noisome painful and fatal disease"

The employment of chimney-boys was eventually made illegal by Act of Parliament It is almost incredible that even to-day there should exist a link with this degrading custom but a centenarian still lives who at the age of twelve worked fifteen hours a day, climbed the insides of chimneys, and swept down soot with a hand brush

The humane disposition of Percivall Pott was displayed in other ways Before he joined the staff of St Bartholomew's, extensive use was made of escharotics and the actual cautery, but Pott condemned the practice and ultimately succeeded in abolishing it Furthermore, he contrived to render surgical treatment as mild as possible, consistent with efficiency, and this principle was reflected in his use at operations of a reduced number of instruments of simple design These reforms were greeted with some contempt by his colleagues who were accustomed to elaboration of technique but Abernethy, a warm admirer, testified to Pott's consideration for the ease and comfort of his patients

He also had a kindly heart towards his dressers, some of whom he took into his own home He took a leading part in improving the instruction of students His lectures were open to all on payment of a small fee and they were well attended He facilitated the diffusion of surgical instruction by selling his own publications at low cost instead of in the conventional form of heavy and expensive volumes His monograph on palsy of the lower limbs in spinal curvature consisted of eighty-three pages and cost one shilling and sixpence, and this venture paved the way for cheap medical text-books

Judging by portraits of Pott he had a pleasing appearance, and dressed according to the fashion of the period, visiting the hospital in his powdered wig, red coat and buckled sword In the words of Earle he was "elegant, lower than middle size" He was an excellent conversationalist with ready wit and a fund of anecdotes He was a devoted son, and made a home for his mother until her death in 1746, after which he married the daughter of Robert Cruttenden by whom he had five sons and four daughters In 1769 he bought a house near Lincoln's Inn Fields and resided in it for seven years when he moved to Prince's Street, Hanover Square At this time Sir Caesar Hawkins, who was reputed to have the best surgical practice in London, retired and Pott succeeded him in professional favour

For the next ten years Pott was much in demand as a consultant and apart from his hospital work he kept up a large correspondence with surgeons and practitioners who sought his opinion and advice from all over the world He was the recipient of many distinctions in 1764 he was elected a Fellow of the Royal Society, the next year he was appointed Master of the Corporation of Surgeons, in 1786 he was elected the first Honorary Fellow of the Royal College of Surgeons of Edinburgh and the year after that an Honorary Member of the Royal College of Surgeons in Ireland These last two honours were conferred upon him at about the time of his retirement from St Bartholomew's Hospital on July 12, 1787, after having, as he said, "served it man and boy for half a century" At the annual meeting of the Hospital subscribers he was elected a Governor and at the dinner that followed there

was a moving scene The Right Honourable Thomas Harley proposed the toast of Percivall Pott who was usually composed and eloquent but on this occasion was overcome with such emotion that after rising to reply was unable to speak and resumed his seat in silence

He continued to practise but his retirement lasted only about eighteen months On December 27, 1788, he died of pneumonia due to a chill which he caught whilst visiting a patient in severe weather twenty miles from London His last conscious words were "My lamp is almost extinguished, I hope it has burnt for the benefit of others" He was buried at Aldermary Church in Bow Lane, close to the remains of his mother

Percivall Pott was a great leader in surgery who shone as a clinical surgeon He flourished before the emergence of surgical pathology under John Hunter, and the deductions from his clinical observation suffered from this lack of scientific interpretation He was, however, particularly free from the shackles of tradition and was bold enough to cut a path of his own In a sense he was more acquainted with the practice of surgery than Hunter but he lacked as they all lacked before the coming of Pasteur and Lister, the one key that saved surgery *from being a tragic adventure*

Percivall Pott is an outstanding figure in the evolution of surgery in Britain He took part in the formation of the Corporation of Surgeons and became its Master, started organised teaching of medical students, and by his humane attitude, good sense and personal integrity helped greatly to raise the status of surgery in this country His writings were clear and composed with scholarly grace, and his observations recorded faithfully without being tedious Their translation into European languages did much to promote the prestige of British surgery abroad

ARTHUR ROCYN JONES

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[This signature is reproduced from a letter preserved in the library of the Royal College of Surgeons of England in which Pott wrote concerning the apprenticeship and indentures of his son We are grateful for permission to reproduce it and also for permission to reproduce one of the two portraits of Percivall Pott which hang in the Council Room of the Royal College of Surgeons —EDITOR]

OTTO KAHLER (1849-1893)

A Centennial Note

How often is there not an element of incongruity, and even of ingratitude, in the way in which the halo of eponymous commemoration encompasses a medical name? That rare and fatal disease, multiple myelomatosis, is known universally in the literature as *Kahler's disease*, in honour of the Prague physician who described it in 1889 For the sake of historical accuracy it may be recalled that this condition was first brought to the notice of the profession in 1846 by John Dalrymple, F R C S , surgeon to the Royal Ophthalmic Hospital, Moorfields London, in a communication "On the Microscopical Character of Mollities Ossium" (Dublin Quarterly Journal of Medical Science, 1846, N S **2,** 85–95) It is recorded that "no suspicion of the affection of the bones existed during the life of the patient and the mollities was only revealed by the post-mortem examination" The patient was attended by William MacIntyre, M D , physician to the Western General Dispensary The urine was examined by Henry Bence Jones, F R S , physician to St George's Hospital Four years later MacIntyre reported this "Case of Mollities and Fragilitas Ossium, accompanied with urine strongly charged with animal matter," in Medico-Chirurgical Transactions (1850, **33,** 211–32) Bence Jones described his test for what is now called "Bence Jones protein" in a paper "On a new substance occurring in the Urine of a patient with Mollities Ossium," which appeared in the Philosophical Transactions of the Royal Society of London, 1848, **138,** 55–62

In the centennial year of his birth it is appropriate to note the part played by Otto Kahler in the history of multiple myelomatosis [1] Born in Prague on January 8, 1849, the son of a doctor, he studied medicine in his native city and did post-graduate work in Paris under Charcot and Duchenne, from whom he imbibed a lifelong interest in neuropathology In 1878 he became *Dozent* at the German University in Prague, and in 1886 Professor of Special Pathology and Therapy Three years later he succeeded Heinrich Bamberger in the corresponding chair at Vienna The story of his life is a sad one Shortly before going to Vienna he noticed a small lump in his tongue which was removed by Carl Gussenbauer but soon recurred A second unsuccessful operation was performed by Billroth in 1890 There were widespread metastases, leading to his death on January 24, 1893, when at the height of his fame, a few weeks after his forty-fourth birthday

Much valuable work was crowded into the few years of Kahler's professional activity He gave the first complete description of syringomyelia in 1888 (Prager medizinische Wochenschrift, 1888, **13,** 45, 63), and in the next year published his paper "Zur Symptomatologie des multiplen Myeloms" in Wiener Medizinische Presse, 1889, **30,** 209–13, 253–5—originally delivered as a lecture before the Verein deutscher Aerzte in Prague on January 11, 1889 [2] His patient was a doctor aged forty-six years It is interesting to note that the author described the presence of albuminuria and the peculiar nature of the protein It is unlikely that at that time physicians in Europe were familiar with MacIntyre's and Dalrymple's accounts Kahler was an excellent clinician, a popular consultant, a lucid and stimulating teacher, and an aristocratic personality with a delightful sense of humour For several years he edited the Zeitschrift fur klinische Medicin and the Prager medizinische Wochenschrift

W R BETT

[1] The term *Multiples Myelom* was first used in 1873 by J von Rustizky (Deutsche Zeitschrift fur Chirurgie 1873 **3,** 162–72)

[2] This paper also appeared in Prager medizinische Wochenschrift 1889, **14,** 33 45 but this I have not seen

DISMEMBRING

WILLIAM BROCKBANK and D LL GRIFFITHS, MANCHESTER, ENGLAND

From the Medical Library of the University of Manchester

Three hundred years ago amputation was one of the few operations which were performed with a technique that had been at all standardised A very good description of the usual technique of those days is included in a remarkable book published in London in 1617 with the title " The Surgeon's Mate, or Military and Domestique Surgery discovering faithfully and plainly ye method and order of ye Surgeon's Chest, ye uses of the instruments, the vertues and operations of ye medicines, with ye exact cures of wounds made by gunshott and otherwise as namely Wounds, Apostumes, Ulcers, Fistulas, Fractures, Dislocations with ye most easy and safest ways of Amputation or Dismembring, the cures of the Scurvey, of ye fluxes of ye belly, of ye Collicke and Iliaca Passio, of Tenasmus and Exitus Ani and of the Calenture with a Treatise on ye cure of ye Plague, published for the Service of His Majesty and of the com wealth by John Woodall "

FIG 1

1545 Amputation is apparently being performed through the knee joint but otherwise the standard technique is used (From Ryff, 1545)

This is one of the great books of British surgery It deals entirely with diseases and injuries of seamen, for " women on long voyages are rare creatures " The advice offered is as thoroughly practical as one would expect from an author who was successively Army surgeon, Surgeon-General to the East India Company, Surgeon to St Bartholomew's Hospital (1616), Naval surgeon (1627) and Master of the Barber Surgeons' Company (1633)

A few extracts from the second, enlarged edition of 1639 (with some modification of the spelling) well describe a seventeenth century amputation with several precepts that are not out-of-place to-day " Amputation or Dismembring is the most lamentable part of chirurgery, it were therefore the honour of a Surgeon never to use dismembring at all if it were possible for him to heale all he undertaketh but necessitie hath no law Since therefore it is of necessary use, let the discreet Surgeon be ever prepared for it and to that end let the Dismembring saw be alwaies in readinesse, well fitted and cleane kept in oyly clowts to save it from rust If you be constrained to use your saw let first your Patient be well informed of the eminent danger of death by the use thereof, prescribe him no certaintie of life and let the work be done with his owne free will and request and not otherwise Let him prepare his Soule as a ready sacrifice to the Lord by earnest prayers craving mercie and helpe unfainedly and forget thou not also thy dutie in that kinde to crave mercie and helpe from the Almightie and that heartily For it is no small presumption to Dismember the Image of God This done have thy other instruments ready namely a good Dismembring Knife, -

FIG 2

1724 An upper limb amputation being performed The technique is similar to that employed for the lower limb (From Heister, 1724)

small incision knife, two great square stitching needles armed with very strong thred waxed and one needle also and thred the ordinary sort to sow rowlers, likewise have ready long clowts, lesser clowts, plegents of tow greater and smaller, dorssels and buttons of tow, three broad strong rowlers or foure, of foure yards long each, with also a forme convenient for to place the Patient on, with a large boule and some ashes therein to receive the blood

"This done and ready place the Patient on the mentioned forme with one strong man set behind him and another to stand before him bestriding his thigh close to his body compassing strongly with both his hands the member which is to be taken off and holding it exceeding fast some two fingers above the place where you intend to take it away, and let another hold up his foot the sharp instruments being as neere you as you can, ever hidden from the eyes of the Patient Then take your dismembring knife and with a steddy hand and good speed cut off flesh, sinews and all to the bone round about the member, which done take a smaller incision knife and divide the panicle called the periosteum from the bone

Fig 3

1646 Wilhelm Fabry (Fabricius Hildanus) was credited wrongly with the introduction of the principle of amputation through healthy tissue above any level of demarcation The main interest in this scene, from his collected works lies in the preparation of cautery irons, otherwise the technique shows no difference from that described by Woodall

It is a tough thin skin, covering all the bones of the body, also thrust your said incision knife betwixt the fossels or bones cutting away whatsoever is to bee found there with like expedition the partie that holdeth the upper part of the legge with all his strength, griping the member together to keep in the spirits and bloud It is also very good for the said partie holding the member and flesh and sinews being cut asunder, should immediately draw or strip upward the flesh so much as he could, keeping his hold that thereby the Saw may come so much the nearer, which would occasion a quicker and better healing, the flesh being thereby made longer than the end of the bone then take the two strong square needle and thread and presently after the member is taken away stitch the skin thorow on the one side and so over on the other side and with the other needle doe likewise as it were crosse over the member the other way and draw the said threds so close as you think convenient the better to st and choake the great veines and arteries, then tye them fast and presently put buttons to the heads of the veins and arteries then apply the restrictive plegets spread with the strong restrictive"

Finally the dressings are applied with a last instruction "then if you will draw on a Swine's bladder which is no evil course" "The work of dismembring is best done in the morning, doe it not willingly the signe being in the place, neither the day of the full Moone, never take off any member in the joynt"

Woodall's text is not altogether original It leans heavily on that written by William Clowes in 1596 and it is to Clowes that Woodall had dedicated "The Surgeon's Mate" The book is illustrated with fine engravings of the instruments contained in the Surgeon's Chest, but as there are no pictures of the instruments in use we have had to seek these from other sources

FIG 4

From a caricature by Rowlandson (1793) Although this is a much later publication it shows despite obvious burlesque that the procedure presents no essential differences from the surgery of 1545 This is one of Thomas Rowlandson s best known medical cartoons and is a very personal caricature of the more eminent doctors of his day

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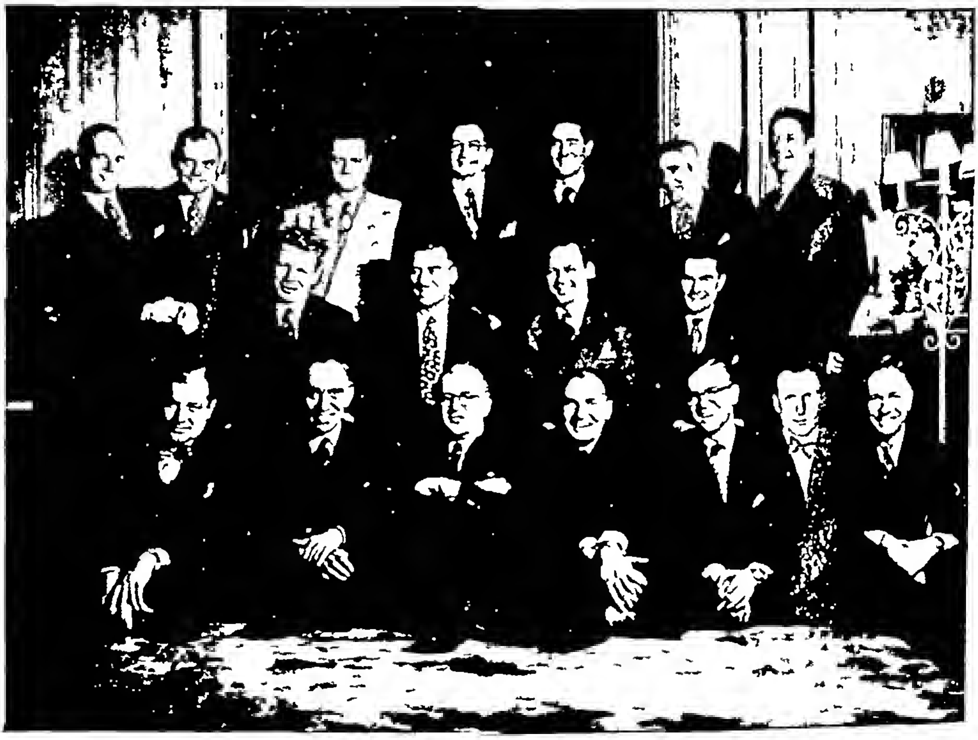
PROCEEDINGS AND REPORTS OF UNIVERSITIES, COLLEGES, COUNCILS AND ASSOCIATIONS

GREAT BRITAIN

BRITISH ORTHOPAEDIC ASSOCIATION—SPRING MEETING, 1949

The Spring Meeting of the British Association was held in Nottingham on April 22 and 23 Papers were presented in the Great Hall of the University The clinical meeting was held at Harlow Wood Orthopaedic Hospital where the president, Mr S A S Malkin, and his colleagues from Nottingham, Mansfield, Grimsby and Derby demonstrated over one hundred cases of particular interest including for example bilateral Volkmann's ischaemic contracture secondary to haemophilia, myositis ossificans progressiva dysplasia epiphysealis multiplex, and familial osteopetrosis non-union after ischio femoral arthrodesis treated by secondary grafting, recurrent deformity after apparently successful grafting of congenital pseudarthrosis of the tibia traumatic spondylolisthesis treated by open reduction with unlocking of the facets congenital spondylolisthesis with sciatic pain treated by removal of the affected disc and posterior grafting idiopathic and paralytic scoliosis treated by grafting, a group of excellently documented cases of tendon injuries and paralysis of the hand, and a number of peripheral nerve injuries demonstrating the results of nerve suture and tendon transplantation



The five Canadian and ten American Travelling Fellows in Orthopaedic Surgery
R Garnepy H Smith J J Fahey, B Obletz, C Larsen, V Inman D W Blanche
W H Bickel J Leo Walker F P Patterson W B McKinnon
L R Straub (Watson-Jones Osmond-Clarke, W Law) B Fowler, F P Dewar J H Allan

Stimulus both scientific and social was gained from the five Canadian and ten American travelling fellows in orthopaedic surgery who attended the meeting—F P Dewar (Toronto) R Garnepy (Montreal) W B McKinnon (Winnipeg), F P Patterson (Vancouver) and J A Leo Walker (Montreal) and J H Allan (Philadelphia) W H Bickel (Rochester) D W Blanche (Los Angeles) J J Fahey (Chicago) S B Flower (Nashville), V T Inman (San Francisco), C B Larsen (Boston) B E Obletz (Buffalo) Hugh Smith (Memphis) and L R Straub (New York) They contributed to the scientific discussion made brilliant speeches at the dinner and founded the A B C Club by which to promote interchange between the orthopaedic services of America, Britain and Canada Other visitors included Professor Delchef and *Dr A C Steenebruggen, from Belgium*

Function of the clavicle—*Dr Verne T Inman* (San Francisco, California) illustrated experiments, including the insertion of transfixion pins into his own clavicle and acromion, and those of his colleagues and students which demonstrated that elevation of the upper limb involved rotation of the clavicle about its long axis, and that fixation of the clavicle to the coracoid process prevented elevation above shoulder level In eight patients the clavicle had been excised completely without loss of function except that extra effort was needed to hold objects above the head The operation was suggested as an adjunct to arthrodesis of the shoulder joint

Anomalies of innervation of the hand muscles—*Mr Tom Rowntree* (London) reported investigation of 688 median and ulnar nerve lesions treated at the Wingfield-Morris Orthopaedic Hospital, Oxford and the Institute of Orthopaedics, Royal National Orthopaedic Hospital, London Only cases with proved axonal division of the nerves had been accepted—102 median nerve lesions and 124 ulnar nerve lesions—the observations being checked in some cases by procaine block of the unaffected nerves The innervation described in text-books was found in 33 per cent of cases—the median nerve supplying abductor pollicis brevis opponens and flexor pollicis brevis, and the ulnar nerve supplying adductor pollicis, the hypothenar muscles and all the interossei The flexor pollicis brevis had a purely ulnar supply in 32 per cent , it had a dual supply from both median and ulnar nerves in 16 per cent There was an anomalous supply in 20 per cent including some with innervation of all hand muscles by the median nerve and others with innervation of all muscles by the ulnar nerve In a few cases procaine nerve block had demonstrated anastomosis between the ulnar and median nerves in the forearm These results emphasized the fallacy of diagnosis of nerve lesions on the evidence of muscle power alone

Extensor apparatus of the digits—*Dr S Benjamin Fowler* (Nashville Tennessee) said that the extensor communis tendons had no useful insertion into the proximal phalanges, and the inability of these tendons to extend the interphalangeal joints of the claw hand depended upon hyperextension of the metacarpo-phalangeal joints If such hyperextension was prevented by tightness of the joint capsules the interphalangeal joints could be extended actively by the long extensor tendons The use of tendon transplants of extensor pollicis brevis, extensor indicis proprius and extensor digiti quinti, to prevent or overcome metacarpo-phalangeal hyperextension and thus promote function after paralysis of the intrinsic muscles, was illustrated

Tendon surgery in the hand—*Mr R G Pulvertaft* (Derby) in a masterly presentation showed some remarkable results of difficult tendon sutures and demonstrated shortening of the dorsal expansion in old cases of mallet finger repair of boutonnière lesions of the extensor expansions, tendon transplantation of extensor indicis proprius for rupture of extensor pollicis longus, suture of divided flexor tendons of the fingers, and replacement of the flexor tendons by tendon grafts

Rupture of extensor pollicis longus tendon after Colles' fracture—*Mr David Trevor* (London) described five cases of spontaneous rupture of the extensor pollicis longus tendon, which he attributed to aseptic necrosis from ischaemia that had been treated by simple bridging of the gap with No 6 Nylon sutures The sutures were removed three months or more after operation Good union had occurred, and photographs of excellent results were shown at intervals ranging up to four years after operation *Mr B L McFarland* (Liverpool) suggested that the ischaemic changes might be caused by strangulation of the tendon in the pulley opposite Lister's tubercle *Mr R G Pulvertaft* (Derby) said that he preferred to transplant the tendon of extensor indicis proprius into the distal part of the ruptured tendon

Pronation fractures of the forearm with special reference to the anterior Monteggia fracture—*Mr E Mervyn Evans* (Birmingham) presented clinical and experimental evidence that the anterior Monteggia fracture dislocation was produced by forced pronation and longitudinal compression In full pronation the radius and ulna crossed in contact and if pronation force continued beyond the normal range of the movement the ulna fractured near its middle and prized the radial head forwards out of the joint Closed reduction by supination without internal fixation had succeeded in nine of eleven cases *Mr F W Holdsworth* (Sheffield) confirmed that "compounding" of this fracture was always forwards In children he treated this injury by conservative measures but in older people he usually plated the ulna Excision of the radial head gave bad results *Sir Reginald Watson-Jones* (London) agreed that the rotatory force of pronation might be responsible when there was a spiral fracture of the ulna but doubted whether this was the mechanism when the fracture was transverse One form of this injury was clearly due to direct injury—the baby-car fracture or as the Americans more picturesquely put it 'the side-swipe' fracture He believed that internal fixation of the ulna by plate or intramedullary nail was often necessary in adults but that open reduction of the dislocated radial head was not usually advisable *Mr W Sayle-Creer* (Manchester) doubted whether supination alone would maintain reduction which was sometimes prevented by the torn capsule

Fractures of the neck of the femur—*Mr P C Elmes* (Oxford) reported a statistical analysis of 115 fractures of the femoral neck treated by closed nailing The clinical results were good in thirty-five cases fair in forty two and bad in thirty eight Anatomical results were estimated in sixty-one cases examined radiographically more than two years after operation Sound bony union had occurred in thirty-nine

cases but there was ischaemic necrosis with collapse of the femoral head in nine of these. Factors which significantly affected the incidence of ischaemic necrosis were sex, site of fracture, interval between injury and operation, interval between operation and weight-bearing, and accuracy of reduction.

Trochanteric fractures of the femur—*Mr R. C. Murray* (Inverness) reported one hundred trochanteric fractures of the femur treated conservatively by simple weight-traction with a medial rotation bandage, early movement being encouraged. He presented strong evidence that with good nursing care the results of conservative treatment were better than the results of operative internal fixation with nails and blade plates. The mortality was lower and the functional results were equally good. *Mr William Gissane* (Birmingham) referred to thirty-two patients with trochanteric fractures treated by the Capener Neufeld nail of whom thirty-one had regained excellent movement in the hip and knee joints. *Mr K. H. Pridie* (Bristol) supported conservative treatment.

Ischio-femoral arthrodesis of the hip—*Mr W. B. Foley* (Oxford) gave a cinematographic demonstration of arthrodesis of the hip-joint of the Brittain type by posterior open approach through a Kocher incision as described by Trumble. Plaster of Paris was applied with the patient still prone.

Lumbo-sacral fusion by metallic fixation and grafts—*Dr L. R. Straub* (New York) discussed lumbo-sacral fusion in eighty cases treated by the method described in 1943 by Dr Philip Wilson in which metallic fixation was combined with the Hibb's operation, supplemented by bone chips, both autogenous and from the bank. One patient died of post-operative shock. Of the others, sixty-nine showed radiographic evidence of sound bone fusion at the end of six months, the evidence being accepted only when several films had been taken in different positions of strain. Failure in five had been at the lumbo sacral joint and in five at a higher level. Recently metallic fixation had been combined with a cortical graft, and twenty-five of twenty-seven patients had shown solid fusion. Among 103 patients treated without metallic fixation there had been three deaths and twenty-nine failures.

Arthrodesis of the ankle by lateral approach and fibular graft—*Dr J. A. Leo Walker* (Montreal) with the aid of most beautiful cinematography and cartoons that might have been devised by Walt Disney demonstrated the technique of this operation in which fusion of the joint was supplemented by fixation of the split fibula to the lateral aspect of the tibia and talus.

Radiological diagnosis of recent lesions of the lateral ligament of the ankle—*Mr J. Roland Hughes* (Preston) said that radiographic examination of the ankle joint in the position of full inversion as described by Watson-Jones was now well-established. He had examined ninety injured ankles and ninety normal ankles. About 6 degrees of tilt represented the transition from normal to abnormal. The lateral ligament was lax when the ankle joint was plantar-flexed and tight when it was dorsiflexed. In the cadaver important tilting did not occur until there had been division of both the anterior talo-fibular ligament and the capsule as far as the lower limit of the articular surface of the talus. It was then possible to tilt the talus through 30 degrees. These ligaments were torn by a movement of plantar-flexion combined with rotation about the medial malleolus. If tilting occurred through more than 18 or 20 degrees there must be rupture not only of the anterior talo-fibular ligament but also of the calcaneo-fibular ligament and the intervening capsule. *Mr J. Grant Bonnin* (London) considered that tilting up to 15 degrees indicated rupture of the anterior talo-fibular ligament, tilting of 15 to 30 degrees rupture of both anterior talo fibular and calcaneo-fibular ligaments, and tilting of more than 30 degrees, rupture of all three parts of the ligament. It was important to X-ray the talus of the uninjured foot which could be tilted about 4 degrees in 10 to 15 per cent. of cases.

Osteochondritis dissecans of the elbow joint—*Mr Norman W. Roberts* (Liverpool) said that osteochondritis dissecans of the elbow joint was almost confined to the male. It was commonest under the age of fifteen years and it affected both elbows in about one-quarter of the cases. The lesion was usually in the capitellum but sometimes in the radial head. There was often diffuse cystic change, detached loose bodies were usually multiple. The radial head was enlarged and premature epiphysial fusion might occur. Association with preceding injury was difficult to establish. When there were loose bodies in the elbow joint radiographs often revealed flattening of the capitellum and pronounced enlargement of the radial head, thus indicating that the source of the loose bodies was unsuspected osteochondritis dissecans rather than osteoarthritis, which was a complication rather than a cause. *Mr H. Jackson Burrows* (London) said that bone in the separated fragment distinguished osteochondritis dissecans from chondromalacia which was often mistaken for it. Osteochondritis dissecans in the elbow joint presented a more complicated picture than the corresponding lesion in the knee. It might be that the knee joint lesion was less simple than had been supposed—or alternatively that the elbow change represented a different and more complicated pathology, possibly akin to osteochondritis juvenilis of the metatarsal head (Freiberg's infraction). *Mr J. Rowland Hughes* (Preston) compared enlargement of the radial head to coxa magna and thought that it might be caused by laxity of the capsule secondary to the changes in the capitellum.

Nerve-root pain of vertebral origin not dependent on disc prolapse—*Professor J Delchef* (Brussels) emphasized that apophysial sprain was a real entity and that arthritis of the posterior articulations might be an important cause of sciatica of single root origin *Mr J R Armstrong* (London) recalled that the first sacral root the most frequently affected, was unrelated to a posterior joint and furthermore that sciatica was not usually relieved by arthrodesis He considered that almost all cases were due to intervertebral disc lesions

Election of Fellows and Members—Elections to fellowship and membership of the Association were made at the Executive meeting —

Corresponding Member P G K Bentzon, Denmark

Fellows F C Durbin, Exeter
J H Mayer Tunbridge Wells
K Stanger Newcastle on Tyne

Associate Members J K Cunninghame, Wellington N Z
Johnstone Dickie, Leicester
P G Essex-Lopresti Birmingham
James Garden Carluke
R N Grant Truro
H H Kennedy, Chesterfield
A W L Kessel, London
H Keith Lucas Liverpool
T H Norton, Grimsby
W A J Pike, Auckland, N Z
C G Rob, Thirsk
F H Stevenson, Stanmore
T E Stoker Cheam
G S Storrs, Bedford
G J Walley, Windsor
R I Wilson Exeter

Clinical Research Sub-committee—At the first meeting of the Clinical Research Sub committee on April 22 1949 it was agreed that policy should be based on these considerations

1) Experimental research was essentially local, and hardly came within the purview of the committee, but much could be done to promote collective clinical research

2) The suitability of subjects for collective research should be determined on the basis of controversial interest, rarity, or a combination of both

3) Any fellow or member who had particular interest in a subject for clinical research should submit his proposal to the committee if possible with the names of those who might collaborate with him

4) If the proposal was supported, a working group of fellows and members would be formed and a chairman selected, the group arranging to meet regularly on the day preceding each meeting of the Association

5) The group should agree on a uniform scheme of documentation and on such variations in investigation treatment as might be desirable and submit their proposals to the Clinical Research Sub committee

6) Requests for financial aid would be transmitted to the Executive of the Association

Clinical subjects were considered and four working groups approved

Traumatic dislocation of the hip joint—Chairman, E A Nicoll
Slipped upper femoral epiphysis—Chairman H Jackson Burrows
Calve s osteochondritis of the spine—Chairman, B E McFarland
Cup arthroplasty of the hip joint—Chairman, H A Law

ROYAL COLLEGE OF SURGEONS OF ENGLAND

Award of the Honorary F R C S to Professor R I Harris (Toronto)—No honour awarded by the Royal College of Surgeons has been acclaimed more generally than that of the jealously guarded honorary fellowship conferred on Dr R I Harris who was twice wounded and twice decorated in the 1914–18 War served as Consultant to the Canadian forces in the recent war is one of the acknowledged leaders of Canadian Surgery Professor of Orthopaedic Surgery in the University of Toronto and recent president of the American Orthopaedic Association He took an important part in establishing British-American co operation in the publication of this Journal and in promoting the travelling fellowship of young orthopaedic surgeons from Britain Canada and America It was fitting that conferment of the honorary fellowship by the President of the College Lord Webb-Johnson should have been witnessed by the five Canadian and ten American surgeons who are the most recent travellers as well as by the thirteen British travellers of last year The audience filled the College to overflowing No sooner had Dr Harris been admitted than he accepted the duty to which every Fellow aspires—the delivery of a Hunterian Lecture

Hunterian Lecture on Spondylolisthesis—*Professor Harris* said that spondylolisthesis was of special interest among the causes of low back pain because of its problems of etiology diagnosis and treatment The essential defect in the neural arch between the superior and inferior articular facets was most common in the fifth lumbar vertebra The defect led to instability of the spine and allowed the body of the affected

vertebra to slip forward carrying with it the superimposed spinal column, while the small posterior fragme maintained its normal relationship to the subjacent vertebra When the defect was present witho displacement the condition was termed spondylolysis In such cases detection was difficult witho oblique radiographs of the spine

Little was known of the cause The defect was said to occur in 5 per cent of adult cadavers but wa not found once in 200 foetuses recently examined and these observations did not support the view tha the defect was developmental On the other hand there was little definite evidence to suggest that it resulted from injury either at birth or in later life Despite much work it had to be admitted that th origin of the defect was unknown

Discussing the clinical aspects Professor Harris said that the two main features were pain an deformity Both arose from instability of the spine Pain was of two types 1) lumbar pain due instability alone aggravated by weight-bearing and activity and relieved by rest, 2) pain from root pressu due either to associated prolapse of the lumbo-sacral disc with pressure on the first sacral root or narrowing of the intervertebral foramina with compression of the fifth lumbar roots When root pai was caused by prolapse of a disc it was usually unilateral but when caused by narrowing of the inter vertebral foramina it was bilateral Deformity was produced partly by anterior displacement of the body of the affected vertebra with the spinal column above it, and partly by secondary compensatory change —increased lumbar lordosis and backward rotation of the pelvis which brought the sacrum more nearly vertical

Careful judgment was required in the choice of treatment, which might be conservative by means of a spinal support or operative by spinal fusion In general fusion was recommended for young patient and those with severe symptoms Occasionally, pre-operative correction of severe deformity was attempted As to the type of operative fusion the transabdominal method was not recommended The anterio graft had to cross the relatively avascular area of the intervertebral disc and the approach did not permit exploration for possible causes of root pressure Posterior fusion was satisfactory if the graft was massive and its anchorage secure The graft should not extend higher than the vertebra above the lesion and adequate post-operative recumbency should be maintained for at least four months In his own clini twin tibial grafts had been used, supplemented with cancellous chips The lower end of each graft was slotted into a window cut in the back of the sacrum above the grafts were anchored to the spinous proce by stainless steel wire In a series of sixty-seven patients treated by operation, the result was satisfactory in fifty-six

ROBERT JONES DINING CLUB

On April 29 1949 the evening of the day that Professor R I Harris was elected an Honorary Fell of the Royal College of Surgeons a meeting of the Robert Jones Dining Club was held Membership this club is limited to the number of those who, on the occasion of Robert Jones' seventieth birthda contributed to the Birthday Volume together with a few distinguished overseas members Dr Harris wa the guest of honour and was elected a member

BRITISH MEDICAL ASSOCIATION—ANNUAL MEETING

ORTHOPAEDIC SECTION, JUNE 1949

At the annual meeting of the British Medical Association held in June 1949 at Harrogate Mr Reginald Broomhead of Leeds presided over the Orthopaedic Section

Structure and functions of the synovial membranes—*Professor D V Davies* (London) described the synovial membrane as the least differentiated joint structure In the embryo it was differentiated fro intersomal mesoderm and was continuous with the cartilage which later formed the bone ends From the beginning, the joint capsule was continuous with the fibrous periosteum The peripheral part of the intersomal mesoderm soon became vascularised and the central area then became a cavity Embryological continuity of the synovial membrane with chondrogenous and osteogenous tissue explained the occasio formation of cartilaginous and bony loose bodies in the synovial membrane The lining cells appropriate called mesothelial cells had been referred to as synovial fibroblasts they could be replaced by the und lying cells but stained differently and showed characteristic reaction to irritation—multiplying enlarg and becoming several layers thick just as did peritoneal cells They seldom became free in the joint flu They were the main source of synovial mucin though not staining characteristically with mucicarmin They behaved differently from fibroblasts in tissue culture secreting a mucinous substance and a proteoly enzyme which liquefied the fibrin medium They took an active part in removing particulate matter fro the joint cavity and in haemarthrosis and villonodular synovitis were often found to be loaded w haemosiderin They probably also removed protein by lysis as seen after transient arthritis T synovial villi, which were scanty in man and increased in number with age were often avascular and t

function was uncertain The synovial membrane contained reticulo-endothelial elements, able to take up tripan blue or gold especially when inflamed The blood vessels were superficial and contributed to the circulus vasculosus which penetrated and nourished the peripheral part of the articular cartilage The nerves which had been studied by Gardner were few they followed the vessels and had no elaborate ending Little was known of the development or function of the fat pads that were characteristic of synovial joints

Varieties of pathological reactions in human synovial tissues—*Dr C H Collins* (Leeds) had examined and studied two hundred and fifty biopsy or autopsy specimens of synovial membrane and recorded the reactions as changes in the synovial cells proliferative and exudative phenomena and leucocytic reactions The synovial cells had three peculiar properties the production of extracellular mucin capacity to form a serosal lining and ability to change into phagocytic histiocytes Malignant synoviomata illustrated the tendency of synovial cells to elaborate mucin and form serosal membranes and phagocytic properties were seen in haemosiderin phagocytosis Giant cells from fusion of histiocytes were found in many conditions including rheumatoid arthritis Haemorrhagic and oedematous reaction took place readily and gave an exaggerated aspect to inflammatory changes Perivascular lymphatic infiltration was massive only in chronic inflammatory conditions like tuberculous and rheumatoid arthritis Lymphocytic aggregates and plasma cells were often found in rheumatoid arthritis Polymorphs were present in small numbers in all chronic inflammatory conditions and entered the joint fluid more readily than lymphocytes All these changes resolved quickly *Mr D Engel* (Dewsbury) had perfused joints in animals after intravenous injection of acid and alkaline dyes None except the acid dyes with small molecules reached the joint cavity, and they did so in proportion to their diffusibility The amount was increased in acute inflammation and reduced in chronic inflammation or after lumbar sympathectomy

Denervation of the hip joint in osteoarthritis—*Mr H Petty* (Leeds) described innervation of the hip joint and said that complete denervation had not been attempted though the danger of producing a neuropathic joint was more theoretical than real Success in relieving osteoarthritic pain had been variable He had followed the practice of Tavernier in resecting the obturator nerve and the nerve to quadratus femoris in nineteen patients Three were completely relieved of pain, twelve still suffered intermittent aching two had more serious pain but were improved and believed that the operation had been worth while two were unimproved It is to be noted that the duration of follow-up averaged no more than three to nine months *Mr H Jackson Burrows* (London) recalled that the simplest denervation of the hip joint was by capsulectomy as practised many years ago by the late R C Elmslie It was most easily done through Kocher s incision

Mould arthroplasty of the hip joint—*Mr R Broomhead* (Leeds) reported one hundred arthroplasties of the hip joint for congenital dislocation rheumatoid arthritis, ankylosing spondylitis, osteochondritis juvenilis slipped epiphysis with late osteoarthritis malum coxae senilis infective arthritis and injury The operation had been performed in patients up to the age of seventy years Technical difficulties included shortness of the femoral neck which might call for trochanteric transplantation and flexion and lateral rotation deformities which tended to persist after operation The results depended not so much on the joint as on the condition of the muscles which was imperfect in old cases of rheumatoid arthritis and ankylosing spondylitis Patients with osteoarthritis due to osteochondritis juvenilis or slipped upper femoral epiphysis regained at least 50 per cent of the normal range of movement and could work all day without pain Young adults with osteoarthritis from other causes regained only about 20 per cent of normal movement but patients with malum coxae senilis the largest group obtained a good return of all movements except rotation Co operation of the patient in after-treatment was imperative the fat woman and the deaf patient presented difficulties The most troublesome complication was new bone formation in the field of operation Two deaths had occurred both shortly after operation Mr Broomhead said that secondary operations—so called revisions—were disappointing The importance of meticulous after care with the use of crutches for six months after operation was emphasized

The role of surgery in rheumatism—*Mr Petty* discussed the treatment of patients with acute rheumatoid arthritis He showed many examples of mould arthroplasty of the hip joint and a most excellent result of bilateral arthroplasty of the knee joints

Physical treatment of arthritis—*Dr H F Turney* (London) reviewed the physical treatment of arthritis of the hip and knee joints by radiant heat and diathermy and active exercises with Guthrie-Smith slings roller skates and the deep pool Pistany packs were just mud Faradism had a place secondary to active exercise Diet played no part save in weight-reduction Intra-articular injection of lactic acid with procaine might be useful but procaine alone and even simple saline injection was no less effective *Mr Grant Waugh* (Sunderland) considered that the acidity of the fluid that was injected was important Procaine solutions were usually prepared from the hydrochloride and were acid Procaine had often to be discontinued because the patient became sensitised

Rheumatology in the United States of America—*Dr G D Kersley* (Bath) recorded observations m... at the Seventh International Congress on Rheumatic Diseases in New York and discussed the bi... chemistry of collagenous and other connective tissues the histology of rheumatoid arthritis and th... hereditary factor in ankylosing spondylitis The subject of most interest was the use of cortisone ar ACTH in rheumatoid arthritis Cortisone was related to adrenal cortical hormones concerned wi electrolyte and water metabolism and ACTH was an anterior pituitary hormone The dramatic improve ment gained on administration of these hormones was equalled by dramatic deterioration on the withdrawal Cortisone had been effective not only in rheumatoid arthritis but also in rheumatic feve gout ankylosing spondylitis, scleroderma, dermato-myositis and generalised lupus erythematosus

Upper limb pain from lesions of the thoracic inlet—*Professor Lambert Rogers* (Cardiff) said th neural pain tingling in type and mostly on the ulnar side of the limb was caused by pressure on the lo trunk of the brachial plexus by a cervical rib or fibrous band, the sharp tendinous anterior margin of scalenus medius or an abnormal scalenus anterior Vascular pain had the aching character of ischaemi and was often associated with cutaneous colour changes It was caused by compression of the subclavi artery between the clavicle and a cervical rib or abnormal first rib The differential diagnosis was fro writer's cramp—a neurosis and irritation of a cervical root by rupture of a cervical disc at the C 5 6 level of which radiological evidence might be found Thirty-three operations had been perform... twenty-five for the scalenus syndrome and eight for costo-clavicular compression *Mr A C Bu...* (Leeds) said that the differential diagnosis should also include Pancost s syndrome caused by compression o the brachial plexus and cervical sympathetic by a tumour at the thoracic inlet with severe pain on the inr side of the limb, wasting of the intrinsic muscles of the hand, Horner's syndrome venous congestion i the arm and neck, and a radiographic shadow at the inlet *Mr H M Hill* (Western Australia) recall... that radiographic evidence of an old cervical intervertebral disc injury did not necessarily imply that th symptoms were related to it

Closed fractures of the shafts of the radius and ulna—*Mr E Mervyn Evans* (Birmingham) said th... in fractures of both bones of the forearm rotation deformities were often left unreduced The key t... orientation of the proximal radial fragment was the radiographic appearance of the bicipital tuberosit... This varied not only with the position of the bone but in different individuals but it was always the same c the two sides of the same individual if the forearms were similarly rotated Antero posterior radiograph... were taken of the normal forearm in positions of 90 degrees, 120 degrees 150 degrees and 180 degre... of pronation An antero-posterior radiograph of the fractured forearm was then taken and the appeara of the bicipital tubercle compared with the various normal films The distal radial fragment w... orientated in correspondence with the known position of the proximal fragment by manual traction a... the resistance of a sling looped over the upper arm, and continued for at least ten minutes Simple pl... of Paris fixation was used Of thirty-five closed fractures with displacement treated conservati... twenty-seven showed less than 30 degrees limitation of movement One needed bone-grafting of radius for non-union and the others united in an average period of eleven weeks *Mr F W Holdsw...* (Sheffield) agreed that rotation deformity had been neglected Difficulties often arose from interpo... soft tissues and from the obliquity or comminution of the fracture and consequently he had adopted op reduction and plating despite the dangers of non-union and infection He had had three cases of infecti... among eighty-five such fractures After operation no external fixation was used *Mr I Lawson D...* (Bradford) agreed that notwithstanding the dangers of plating there were some fractures that demar... it notably those of the lower part of the radius with radio-ulnar subluxation *Mr H H Lan...* (Southampton) endorsed the importance of rotation deformity but urged that open operation should n... be used routinely *Mr N Ross Smith* (Bournemouth) considered that even when open reduction ... required, internal fixation, with its risk of delayed union should be avoided if the fragments could b... interlocked *Mr G A Pollock* (Edinburgh) agreed that internal fixation should be avoided *Dr F H... Hanford* (Northern Rhodesia) considered that the risk of infection in open reduction had b... underestimated *Dr H M Hill* (Perth Western Australia) agreed that plates were often nece... their use might be supplemented by grafting with iliac bone to accelerate union

ROYAL SOCIETY OF MEDICINE

SECTION OF ORTHOPAEDICS—1949

Practical value of peripheral nerve repair—*Mr H J Seddon* gave his presidential addre... February 1 1949 He pointed out that apart from Stopford s data published after the first World War ... were few accurate accounts of the end-results of nerve suture Opinions ranged from uncritical optimi... the success of primary nerve suture to profound pessimism as to the failure of secondary repair o... sciatic and ulnar nerves The five Nerve Injury Centres set up in Great Britain at the beginning of... second World War had achieved remarkable uniformity in documentation and the Medical R... Council now had records of a very large series of cases traced for periods of three to five years

The proportion of good recoveries increased steadily up to three years after suture, but there was little change between the third and fifth years The figures were encouraging and selected cases were demonstrated to show what was meant by good recovery one man could climb telegraph poles after sciatic nerve suture another played squash one was able to ski after suture of the lateral popliteal nerve

There were three unavoidable causes of failure 1) Recovery was usually imperfect when the nerve lesion was so proximal as in injuries of the brachial plexus Except in the case of lesions of the upper trunk, little if anything was to be gained from operative repair at this level 2) Associated injuries to blood vessels muscles tendons and joints sometimes precluded useful recovery, though it was remarkable how many limbs formerly considered to be damaged beyond repair could be made useful 3) Some lesions, such as traction injuries and ischaemic damage of main nerve trunks were too extensive for repair by any means at present available

The avoidable causes of failure were more numerous Stiffness of joints and shortening of muscles should be avoided at all costs The remedies were simple preservation of mobility by careful passive movements limitation of splinting to that which was needed to prevent overstretching of muscles, and control of muscle atrophy by electrical stimulation

Delay in repair of a severed nerve was harmful because 1) Schwann cells, which were responsible for the formation of a cellular bridge between the sutured stumps reached a peak of activity some few weeks after division and thereafter lost their power of proliferation 2) shrinkage of Schwann tubes caused by Wallerian degeneration in the peripheral stump became irreversible so that outgrowing axons were unable to attain the diameter necessary for their proper function 3) the motor end-plates atrophied and disappeared and after late suture were usually replaced by inferior structures 4) atrophy and fibrosis of denervated muscle was progressive and ultimately irreversible, 5) sooner or later the peripheral stump shrank to such a degree that accurate apposition became impossible

It was of course desirable that a nerve should be repaired with the least possible delay but even in favourable circumstances primary suture had not always given satisfactory results Zachary and Holmes had compared a series of cases treated by primary suture with similar cases dealt with by early secondary repair There were many satisfactory results after primary repair but, as a whole the results were far superior in cases treated by early secondary repair It was often found that even wounds that appeared to be cleanly incised caused severe intraneural changes which became evident later as zones of fibrosis Sometimes the suture was technically unsatisfactory because of the poor state of the epineurium In other cases separation of the stumps resulted from dragging at the suture line when the flexed joint was extended All these hazards could be avoided by the delayed operation, at which it was possible to mobilise the nerve adequately and place the line of suture in favourable surroundings

When complete paralysis was associated with an open wound the policy should be to explore the nerve within a few weeks of healing of the wound because complete division was found in over half the cases Resection was indicated if there was unmistakable evidence of intraneural fibrosis in an undivided nerve or if there was any but the most trivial incomplete division

Imperfect recovery was sometimes due to inadequate mobilisation of the stumps especially after wounds at the wrist In half these cases mobilisation as high as the elbow was required Conversely, over-ambitious attempts to close large gaps by mobilisation and acute flexion of joints gave poor results There was a biological limit to the length of gap that could be closed with safety and, when very large gaps had been closed later straightening of the limb had inflicted serious traction lesions There was a critical length of resection for every nerve and a gap approaching or exceeding this was better closed by autogenous grafting which had now been proved reliable Inadequate resection of the stumps was an uncommon cause of failure but mistakes were occasionally made in taking too little from the peripheral stump which might suffer ischaemic change particularly after wounds of great violence There might also be failure due to post-operative separation at the suture line by a haematoma This could be detected by radiography after attaching to the stumps, close to the suture line, opaque inert markers—small gold plates

In closed fractures with nerve injury there was division of the nerve trunk in only one case in five, in all others good recovery occurred spontaneously Exploration should therefore be limited to those cases in which signs of recovery failed to appear in the time required for axons to grow from the site of damage to the most proximal of the paralysed muscles

Amputation surgery and limb-fitting—The Summer Meeting of the Section of Orthopaedic Surgery was held on June 25 1949 at Queen Mary s Hospital Roehampton—the main centre in Great Britain for amputation surgery and limb-fitting The morning was occupied by clinical demonstrations of the preparation of stumps for prosthesis the methods used in limb fitting the new suction socket for the lower limb and improved types of upper limb prosthesis *Mr L Gillis* (London) emphasized the importance of co operation between experienced surgeons and limb makers Vast experience gained in the Ministry of Pensions had proved invaluable in determining the length and characteristics of the perfect stump and surgeons should accept the recommendations of limb-fitting specialists A careful technique was essential

All bleeding vessels should be ligated meticulously Coagulation by diathermy should be avoided The deep fascia should be sutured to ensure freedom from adhesion between skin and deep tissues In children epiphysiodesis was useful in preventing disproportionate growth of bone and soft tissues The problem of painful phantom limb remained unsolved

Painful stumps—*Dr Dimant* said that pain might arise from skin, scar tissue, muscle or bone or from the effects of vascular impairment An analysis of 600 cases of painful stump was presented

The fitting of short stumps—*Dr McKenzie* discussed difficulties in fitting short thigh stumps Function was more natural with a well-fitted above-knee prosthesis than with a tilting-table In the past it had seldom been possible to fit a stump-controlled prosthesis with less than six inches, but a stump as short as four and a half inches could now be fitted satisfactorily

Traumatic skin loss below the knee—*Mr R Batlle* discussed skin replacement by thin Thiersch grafts dermatome grafts local flaps cross-leg flaps and tubed pedicle grafts A free Thiersch graft was often satisfactory even when applied directly over bone if it proved unstable it could be replaced later by a pedicled graft Local flaps were potentially dangerous, particularly in unskilled hands The length of the flap should never be greater than twice its width Cross-leg flaps were convenient because the proximity of donor and recipient areas allowed direct transfer Tubed pedicle grafts were often preferred because of the healthy and supple character of the transferred skin The usual technique was to carry the skin on the wrist from abdomen to leg

UNIVERSITY OF OXFORD

NUFFIELD PROFESSOR OF ORTHOPAEDIC SURGERY

Josep Trueta who has been elected Nuffield Professor of Orthopaedic Surgery in the University of Oxford was born a Catalan in Barcelona on October 28, 1897 son of Raphael Trueta, physician in Barcelona and great-grandson of Antony Trueta surgeon of the Army of General Lancaster in the war between Spain and France in 1795 In 1929 he was appointed chief surgeon of the " Caja de Prevision y Socorro an organisation treating 40 000 accidents a year In 1933 he was elected assistant professor of surgical pathology in the University of Barcelona and in 1935 became chief surgeon to the " Hospital de la Santa Creu i Sant Pau, Barcelona

Josep Trueta of Barcelona who has been appointed Nuffield Professor of Orthopaedic Surgery in the University of Oxford

In 1936 the Spanish Civil War began Trueta's position as chief surgeon of the largest hospital in Catalonia, and one of the largest accident services in Spain, gave him the opportunity of developing a method of treatment of war injuries that was later used extensively in the treatment of casualties in the Allied Armies On February 27, 1939 he reached this country at the invitation of surgeons who had seen his work in Barcelona and in September he was invited to join the staff of the Wingfield Morris Orthopaedic Hospital

His publications which are too extensive to be listed here comprise thirty-two papers on civil orthopaedic surgery twenty on the surgery of war and six contributions to the literature of crush syndrome and the renal circulation He is also author or joint author of six books on the surgery of peace and war

In 1940 he was elected an Honorary Fellow of the British Orthopaedic Association and in 1943 was awarded the D Sc Honoris Causa by the University of Oxford In 1947 he gave the Balfour Lecture in the University of Toronto and the Annual Lecture on Surgery at the Royal College of Physicians and Surgeons of Canada He was elected an Honorary Fellow of the Royal College of Surgeons of Canada In 1948 he gave the Carmalt Lecture, Yale, and the Friesner Lecture, Mount Sinai Hospital New York, and he was presented with the Prix Laborie with special medal of the French Acadamie de Chirurgie

Trueta s name has been associated particularly with the closed plaster treatment of wounds It is perhaps not fully realised that while credit is due to Winnett-Orr for the closed plaster treatment of osteomyelitis whether of haematogenous origin or associated with compound fractures Trueta s practice differed in that his closed plaster was part of the initial treatment of gunshot wounds and other open injuries and that he insisted that the plaster should be applied only after complete excision of all contaminated devitalised and ischaemic tissues Trueta emphasized the importance of rest of soft tissues as well as of bones particularly in relation to tissue infection In organising the reception of air-raid casualties he had learnt that the interposition of a first-aid post between the " incident and the hospital gave rise to delay that was harmful and was needless in all but minor and superficial wounds

Trueta who was a professor of surgery and leader of the profession in his own country, came to England at the request of British surgeons and offered the fruits of his unique experience in the Spanish Civil War He has played a valued part in all the clinical activities of the hospital in Oxford His appointment as Nuffield Professor of Orthopaedic Surgery will add distinction to the Wingfield-Morris Orthopaedic Hospital and the Oxford Medical School

REGIONAL ORTHOPAEDIC MEETINGS IN GREAT BRITAIN

SOUTH-WEST ORTHOPAEDIC CLUB

A meeting of the South-West Orthopaedic Club was held in Truro on May 14 1949 at the Royal Infirmary under the chairmanship of Mr J H Hood

Congenital club foot—Unselected cases of talipes equino-varus were shown at all stages of treatment The treatment favoured was manipulation and fixation with strapping Points of interest that emerged in discussion were 1) despite good initial correction relapse with inversion of the heel was liable to occur at about the age of eighteen months, 2) the calf muscles showed hardening and atrophy at the same age 3) associated torsion of the tibia appeared to be more common than with the Denis Browne method of treatment

Spina bifida with meningocoele—*Miss Forrester-Browne* pleaded for conservative treatment of spina bifida The skin usually broke down because of the contact of moist ' nappies By means of a perspex shield shaped like a tunnel and open at both ends the skin could be protected and kept dry The meningocoele then shrank to proportions not requiring surgery

Dupuytren's contracture—*Mr Rentoul* discussed the operative treatment of Dupuytren's contracture A longitudinal incision was used, regardless of skin creases and the thickened fascia together with its phalangeal prolongations was excised No splintage was used Six cases with excellent results were demonstrated It was claimed that a longitudinal incision did not cause contracture or keloid change and that it facilitated the technique of operation and reduced the likelihood of sloughing There was a lively discussion on the merits of subcutaneous tenotomy

Other discussions—*Miss May* discussed the treatment of pneumococcal arthritis of the knee joint by chemotherapy *Mr Price* demonstrated Calve s disease of the spine with regeneration of the affected vertebra *Mr R A Grant* outlined the organisation for the treatment of injuries in Cornwall *Mr E J Kn can* discussed the manipulative and operative treatment of Monteggia fracture-dislocations *Dr F Wilson* geriatrician for the Cornwall area, outlined plans for the rehabilitation of old patients with chronic polyarthritis

INSTITUTE OF ORTHOPAEDICS

ROYAL NATIONAL ORTHOPAEDIC HOSPITAL LONDON

Visitors' week—A group of European surgeons who visited the Institute of Orthopaedics in February 1949 included Drs Benassy Descamps Mears Radadier and Vigneau from Paris, Dr Nievergelt from Zurich Dr Sibay from Leyden Drs Vereecken and Verjans from Ghent Drs Coquelet and de Marneffe from Brussels Dr Steenebruggen from Liège Dr Parisel-Leclercq from Ostend Dr van de Voorde from Antwerp and Dr Jacobson from Oslo The treatment of peripheral nerve injuries was reviewed by Mr H J Seddon and Mr D M Brooks The technique of cup-arthroplasty of the hip joint was discussed by Mr J I P James The technical details of clinical photography of orthopaedic cases was presented by Mr Whitley

At the country branch of the hospital modern methods of treatment of poliomyelitis were demonstrated in the gymnasium and swimming pool Mr J T Scales demonstrated the use of plastic material in orthopaedic splintage The standard treatment of tuberculosis was presented by Mr E J Nangle Clinical cases were shown by Mr K I Nissen and Mr J A Cholmeley Methods of plastic surgery were demonstrated by Mr Matthews

One day was spent at Luton where Mr L W Plewes and Dr Anderson showed the organisation of the accident service at the Luton and Dunstable Hospital and the rehabilitation service that has been established in the Vauxhall Motor Works Another day was devoted to the study of handicapped children at the School for Physically Defective Children Willesden where Miss Pritchard demonstrated the efforts of achondroplasics patients with muscular dystrophy, and other crippled children in their group drill to music The Cripples College of the Royal National Orthopaedic Hospital and its associated workshops were visited under the guidance of Colonel Churchill On the last day a visit was paid to Stoke Mandeville where Dr Guttmann showed recent advances in the early treatment and late rehabilitation of patients with traumatic paraplegia

It is hoped that this visitors' week, which began with a welcoming speech in French by Mr H J Seddon and finished with a visit to Twickenham where France and England met in a rugby football match will be the forerunner of similar visitors' weeks in future years

Lecture by Professor Gruca—Dr Gruca, professor of orthopaedic surgery in the University of Warsaw gave a lecture at the Institute of Orthopaedics, in February 1949 on Excision of the Hip with Osteotomy for the Restoration of Movement after Tuberculous Infection

ROBERT JONES AND AGNES HUNT ORTHOPAEDIC HOSPITAL

In recent numbers of the Journal it was recorded that much of the Robert Jones and Agnes Hunt Orthopaedic Hospital had been destroyed by fire Subscriptions began to pour in within a few days Safe in the confidence of the support that this hospital commands from many thousands of former patients and voluntary workers in this and many other countries rebuilding was begun almost at once If any had doubted the wisdom of such confidence their doubts have now been resolved The subscription list totals £41 000 The spirit of voluntary effort is not dead

MEMORIAL TO DAME AGNES HUNT

It was one of the ideals of Agnes Hunt that cripples should be relieved from the hardships of institutional life and be allowed to enjoy the comforts and privacy of a normal home, and as a memorial to her it is proposed to create a village for disabled persons in the region of the Robert Jones and Agnes Hunt Orthopaedic Hospital and the Derwen Cripples Training College The village will consist of bungalows some to accommodate one or two individuals and others to house the family of crippled parents It will include community and recreational facilities The cost of each bungalow will be in the region of £1500 to £2000 and they will be named in accordance with the wishes of the donors

The cost of rebuilding the hospital was met almost without appeal—but this is a new demand and an appeal is now being made to all those who believe that the memory of Agnes Hunt should be perpetuated

PORTLAND TRAINING COLLEGE FOR THE DISABLED—HARLOW WOOD

Princess Elizabeth laid the foundation stone of the Portland Training College for the Disabled Harlow Wood Nottinghamshire on June 29 1949 Describing the objectives of the College which will be associated closely with the Harlow Wood Orthopaedic Hospital, Mr S A S Malkin said that it was through the initiative of a few citizens of Nottingham led by the Duchess of Portland that the orthopaedic hospital came into being in 1929 Since then it had grown and prospered and was rendering an important service to the district But no matter how great the advances of medical science, there would always be some who, on account of the severity or the nature of their disabilities, would never return to their former occupations To them the future seemed black Nevertheless with special training, most of them could be made fit for new work suited to their abilities They would become self-supporting independent and happy members of the community It was to give this training and opportunity that the Portland Training College was being built The College would serve mainly the four counties of Nottinghamshire Derby Lincolnshire and Leicestershire It would be established on a voluntary basis outside the sphere of the National Health Service

MINERS' WELFARE COMMISSION

REHABILITATION OF INJURED MINERS

In the annual report of the Miners Welfare Commission for 1948 which was published recently, the consulting surgeon Mr E A Nicoll reviewed the growth of the present rehabilitation service He recalled that ten years ago the word "rehabilitation" was practically unknown in the medical world, yet its value was already recognised by a few pioneers As early as 1935 a rehabilitation clinic had been established in the Lanarkshire coalfield by Alexander Miller of Glasgow The importance of reinstatement of injured men in the working community was beginning to be recognised but at that time the machinery for co-ordinating rehabilitation and social service was lacking In 1939, Berry Hill Hall, near Mansfield, was opened as a rehabilitation centre with one surgeon and one physiotherapist, and with accommodation for fifteen patients Although the Centre was started as an experimental project its value was quickly recognised by the coal owners who agreed not only to make it permanent but to extend it to accommodate forty patients In 1942 the Ministry of Fuel and Power requested the Miners' Welfare Commission to provide similar facilities throughout Great Britain A medical advisory committee was appointed under the chairmanship of Sir Reginald Watson-Jones with Mr E A Nicoll as consulting surgeon To-day there are eight centres serving all the major coalfields, and three associated schemes serving the minor coalfields of Cumberland Kent and North Staffordshire

The results of the year's work are impressive No less than 92 3 per cent of injured patients treated in the centres were able to return to useful and economic work in the pits and of these 63 per cent resumed their full pre-accident work These figures represent the results of the more difficult cases occurring in the mining area—many lesser injuries do not require the elaborate facilities for treatment and social service that have been built up at the centres

In the clinical field the extensive accummulation of well-documented material for analysis and review will form a valuable contribution to clinical research Already small teams of surgeons are concentrating on the investigation of clinical problems that are so uncommon that it would take one surgeon, working alone almost a lifetime to solve them

AUSTRALIA

AUSTRALIAN ORTHOPAEDIC ASSOCIATION

Membership of the Australian Orthopaedic Association now includes forty active members twelve associate members, three honorary members and ten corresponding members The 1949 annual meeting was held in Sydney from June 1 to 4 The main subjects for discussion were Surgical tuberculosis by *Mr D W L Parker* Treatment of fractures about the elbow joint by *Mr W R Gayton* Treatment of slipped epiphysis of the femur by *Mr E F West* and The role of tendon transplantation in restoration of function after paralysis by *Mr H Crawford*

The Association welcomes the formation of a Postgraduate Education Committee by the Royal College of Surgeons of England and will advise regarding Australian applicants for post-graduate orthopaedic training in Great Britain

INDIA

SOCIETY FOR THE REHABILITATION OF DISABLED AND CRIPPLED CHILDREN

The Society was envisaged in 1947 by a group of voluntary workers and became a registered society in October 1948 Its objects are to organise hospitals and clinics for the diagnosis care and treatment of disabled and crippled children to educate public opinion on the problem of such afflicted children and to collect statistics relating to it Although the work of the Society has so far been restricted to the Bombay area it is hoped that it may ultimately be expanded to deal with the problem of crippled children throughout India The finding of suitable premises has been a major difficulty At present the work is being carried on in a military hutment converted for use as an out-patient physiotherapy and rehabilitation clinic The clinic is staffed by ex-army physiotherapeutic technicians under the direction of a panel of doctors Dr M G Kini, M C M Ch (Orth) has been appointed orthopaedic surgeon to the society

Up to the end of 1948, 233 patients had been accepted for treatment Most were cases of poliomyelitis There is no distinction as to caste creed sect, nationality or class Transport to the clinic is provided Rapid expansion of the activities of the society is foreseen Within the next two years it is proposed to establish a children's orthopaedic hospital on the most modern lines to organise a teaching institution for the supply of trained physiotherapists to establish an orthopaedic workshop to found a school for crippled children and to set up an institute for research into the problems of poliomyelitis

CZECHOSLOVAKIA

CZECHOSLOVAK SOCIETY OF ORTHOPAEDIC SURGERY

The annual meeting of the Czechoslovak Society of Orthopaedic Surgery will be held in Prague September 24–25 1949 The subjects for discussion will include the general treatment of fractures and osteoarthritis

GREECE

PRESENT STATE OF ORTHOPAEDIC SURGERY IN GREECE

Mr St J Buxton (London) was invited recently to make a visit to Greece with the purpose of surveying and reporting upon the present state of orthopaedic surgery in that country and the main problems that are being encountered in its development

War surgery—Surgeons working in the army particularly at the base hospitals in Athens and Salonika had had great experience of military surgery and the standard of operative work was high Surgery in the forward area also appeared to be performed competently as judged by the low incidence of infection in wounds and compound fractures evacuated to base hospitals The value of infrequent dressings of limb wounds was not fully recognised and it was still a common practice to cut windows in the plaster for daily dressing The treatment of peripheral nerve injuries did not include all modern methods of investigation and tendon transplantation at the wrist was often carried out before the radial nerve had been explored with a view to suture

Amputations—It had been estimated that about 2500 amputations were performed between 1940-45 and that the total number of amputees was about 4000 Ten per cent of amputations were of the upper limb The standard levels of amputation were known and practised, but many unhealed granulating stumps resulting from the guillotine type of operation were seen Limb-fitting showed some lack of co-operation between the operating surgeon and the limb factory

Civilian orthopaedic surgery and the care of crippled children—Although the treatment of injuries was under the care of general surgeons the speciality of orthopaedic surgery was recognised and there was a number of experienced surgeons who had travelled to study the methods used in other countries Methods of investigation radiography and operative treatment were of a high standard Surgical tuberculosis was prevalent There was an excellent pavilion type hospital at Voula Immobilisation of tuberculous joints was much less strict than in Britain Streptomycin was used when abscesses were present

Rehabilitation and physiotherapy were not yet fully developed in their application to war surgery, civilian accident work, or the treatment of long term orthopaedic cases

GERMANY

The German Orthopaedic Congress—The Orthopaedic Congress was held in Munich on April 21-23 under the presidency of *Professor G Hohmann* Congenital dislocation of the hip joint was discussed by Professor Lanz (Munich) Professor Scaglietti (Florence) Dr Rohlederer (Esslingen) Professor Pitzen (Münster) Dr Niederecker (Wurzburg) Dr Detzel (Munich), Professor Schede (Sandersbusch) Professor Lindemann (Hanover) Dr Hepp (Hamburg), Professor Hackenbroch (Cologne) and Professor Storck (Giessen) The discussion continued throughout the whole of the first day and covered the pathology of preluxation and subluxation, the indications for early preventive treatment the management of contracture and late stiffness the problems of torsion and coxa valga luxans and treatment by plastic reconstruction of the acetabular roof and rotation osteotomy On the second day deformities of the hands and fingers were discussed by Professor Weil (Heidelberg) and Dr Witt (Bad Tolz) Rehabilitation and training of the disabled was discussed and at a visit to Bad Tolz, demonstrations were given by Professor Max Lange

MEXICO

Mexican Society of Orthopaedic Surgery—The Mexican Society of Orthopaedic Surgery was established in 1944 and its activities are being extended *Dr Luis Garcia Figueroa* is president of the Board and secretary is *Dr Ladislao Solares* The Society includes sixteen charter members three active members and two honorary foreign members Correspondence is welcomed the Secretary s address is Sinaloa Mexico, D F

CORRESPONDENCE

Polyostotic Fibrous Dysplasia—Albright's Syndrome—*Mr Charles K Warrick* (Newcastle upon Tyne) writes to point out that in his paper on Polyostotic Fibrous Dysplasia published in this Journal May 1949 (volume 31-B No 2, page 180) the height of the patient Case 2 J M was recorded 5 feet 11 inches but should have been 5 feet 1 inch

Book Reviews

ESSENTIALS OF ORTHOPAEDICS By Philip WILES, M S F R C S, F A C S, Hon Orthopaedic Surgeon Middlesex Hospital and King Edward Memorial Hospital Consulting Orthopaedic Surgeon, Royal Surrey County Hospital Formerly Brigadier, A M S Consulting Surgeon (Orthopaedics) Middle East Force and Persia and Iraq Force and Consulting Surgeon Eastern Command India, and 12th Army, S E A C 10×7 in Pp xv+486 with 365 text-figures and 7 coloured plates Index 1949 London J & A Churchill Ltd Price 42/–

Mr Philip Wiles has addressed himself to the task of expounding the essentials of orthopaedics for the benefit of the undergraduate student the surgical resident and the general practitioner It is unlikely that any two senior clinical teachers will agree on what is 'essential in any field of medicine or surgery Every monograph is bound to reflect the writer s perspective view of the situation which confronts him But in actual fact it is the personal "slant ' which makes this attractively written work of Mr Wiles so appropriate for his chosen audience The book opens with an excellent chapter on postural defects—a subject which the author made his own some years ago This is followed by a chapter on back pain, full of practical common sense The reader is thus introduced to the core of clinical orthopaedics at the outset This approach deserves the highest praise Later sections are conventionally devoted to pyogenic infections tuberculosis of bone and joint chronic arthritis tumours of bone other bone diseases and diseases of the central nervous system Apart from these selective chapters orthopaedic disabilities are described in their anatomical relationship to the joints of the trunk and the upper and lower limbs It would be easy to criticise the relative space allocated to particular topics for instance twenty pages on bone tumours with a tendency to over emphasis on rarities (e g Fig 327) and only the same number of pages for the chapter on chronic arthritis in which it must be admitted Mr Wiles has managed to condense the essential features of modern orthopaedic practice There are also some notable omissions doubtless in the cause of brevity A chapter on the principles of fracture treatment—not an easy subject to present in synoptic fashion—would have been valuable and we miss the historical approach and bibliography of classical references so important for the intellectual stimulus of the undergraduate and house surgeon The work is bound to take its place amongst the popular student text books future editions will undoubtedly be called for and Mr Wiles will be tempted to expand his admirable book The selection of essentials will not be easy but by reason of his ripe experience and sound judgment he is well fitted to undertake it —HARRY PLATT

FIG 35
Two methods of manipulating the dorsal spine

SOURCE BOOK OF ORTHOPAEDICS By Edgar M Bick M A M D, F A C S Dipl Orth Surg Associate Orthopaedic Surgeon, The Mount Sinai Hospital New York one time Regional Consultant Orthopaedic Surgeon (Army) European Theatre of Operation Second edition 9½ × 7 in Pp xii–540 with 31 figures Index 1948 Baltimore The Williams & Wilkins Company Price $8 00 (44/–)

The arrival of the second edition of Dr Bick s admirable source book has been long awaited It is doubtful whether this book is well enough known particularly in Britain and it is to be hoped that this new edition will give the work the very wide recognition which it deserves for it is unique up to date authoritative and very interesting It is far more than its title implies Besides representing a commendably complete and very painstaking collection of the sources and original papers upon which modern orthopaedic surgery is based it is an interesting and exciting account of the development of our art and science It should be read for pleasure and for profit by all who are interested in the historical background of our craft and should form part of the compulsory reading of anyone who thinks that he has devised a new operation a new technique or a new theory

Revision and recasting have been very thorough The first part of the book (which deals with orthopaedic surgery before 1900) has been revised but is substantially what it was Of the five new pages which have been added to this section most are taken up with new illustrations The second part of the book however (on contemporary orthopaedic surgery and its recent sources), has been nearly doubled in length and has been brought well up to date There are, for example admirable surveys of the surgery of the Second World War of the modern views of the physiology of bone and of their development, and even of such subjects as genetics as applied to orthopaedic surgery There is a useful, if admittedly incomplete list of orthopaedic journals and an interesting but necessarily brief account of the development of orthopaedic hospitals The many excellent features of this book make its one grave fault—a series of irritating mistakes probably due to poor proof-reading—particularly regrettable the more so because some have remained uncorrected since the first edition Colins Mackenzie " (p 10), Filkin of Northwick (p 76) Abernathy (p 82) Intercranial haemorrhage ' (p 4) a mistake in the sex of Miss Honor Fell (pp 94–95), Fairbanks for Sir H A T Fairbank (p 167), ' is for " his " (p 208) and ' Coffee for Coffey (p 211) are among the jars which upset the reader One must also criticise Dr Bick's rather ready acceptance of oft-repeated surgical legends which are probably quite untrue (such as the idea of the introduction of the ligature by Pare and of amputation above the line of demarcation by Fabry) and of some stories which are certainly false (such as the statement on p 79 that Pott sustained a Pott s fracture whereas the injury which he did sustain in 1756 was a compound fracture higher up the leg) The greatness of Sherrington s contribution to orthopaedic surgery albeit an indirect one is not clearly realised and a British reader may be forgiven for pointing out that the surgical history of the Second World War did not begin at Pearl Harbour These are however, remediable faults for this is a fine book, stressing once again that what is considered modern ' is but the sum total of previous observations re-classified re interpreted and occasionally multiplied a lesson which none of us can rehearse too often —D Ll Griffiths

THE BRITISH JOURNAL OF SURGERY War Surgery Supplement No 2 WOUNDS OF THE EXTREMITIES Five reviews collected and edited by H J Seddon, D M, F R C S 10 × 7½ in Pp x–271–374, with 74 figures 4 in colour 1949 Bristol John Wright & Sons Ltd Price 12/6

The time has now come when the surgery of the last war although still fresh in mind can be seen in proper perspective and the editors of the British Journal of Surgery are to be congratulated on producing the series of War Surgery Supplements of which this volume is the second It is essential that progress made during the war is accurately and concisely recorded, and, of the several methods available the one chosen here a series of reviews by representative surgeons is undoubtedly the best Mr Seddon has been happy in his choice of contributors because they have not only given an accurate account but they have also managed to convey the sense of urgency peculiar to war surgery, that arises from the pressure of a seemingly unending stream of casualties piling up at the front door

The outstanding improvement in the medical services in this war lay in the administrative appreciation that no surgeon can do his work properly unless the patient reaches him quickly and in as good condition as possible unless he has modern means of resuscitation at hand, and unless he has good lines of communication behind him F A R Stammers describes in the opening article how these things were achieved in the Italian Campaign He follows the wounded man until his arrival at a base hospital and deals with first aid resuscitation chemotherapy splintage transport the general principles of primary surgical treatment and the modifications that may be necessary to suit varying local conditions It is the most authoritative and succinct review of this subject yet published and it might well be learnt by heart both by those planning the Army Medical Services of the future and the surgeons enrolled in it Stammers is perhaps over modest about the part he played, together with his fellow-consultant Harold Edwards in planning the med -

organisation of the Italian campaign, for it was they who arranged the first large scale experiment in delayed primary suture which proved so successful that it rapidly superseded the routine use of closed plaster methods. Ronald Furlong and J. M. P. Clarke contribute a valuable account of the treatment at base hospitals of missile wounds involving bone. They discuss first the general principles concerned and then special difficulties encountered at selected sites. Their experience is particularly instructive because they received their patients direct from the forward surgical units and were able to hold most of them for definitive treatment. J. C. Scott records the remarkable change in the prognosis of penetrating wounds involving joints that has come from improved methods of splinting during transport and from chemotherapy. Even at the time of the North African Campaign in 1942 the mortality and the amputation rates in wounds of the knee had both been reduced to one quarter of the 1917 figure, and by 1945 they were negligible. In spite of the remarkable results achieved by New Zealand surgeons, and later by many others, with very early mobilisation of missile wounds of the elbow, Scott still prefers to fix the elbow until healing is complete. H. J. Seddon's knowledge of peripheral nerve injuries is unrivalled, and no more worthy pen could be employed to present the long-awaited results of the experiences of this war. One cannot help marvelling—as he describes in succession non-operative treatment, the indications for primary and secondary operative repair, nerve-grafting, and, finally, the end-results of suture—at the immensity of the painstaking labour continued day after day for years that has made this record possible. The end-results are assessed on the basis of the objective criteria elaborated by the Nerve Injuries Committee of the Medical Research Council, and he now makes available, for the first time, the really reliable information that is essential if the surgeon is to reach a rational decision as to his conduct in a particular case. J. J. Mason Brown, in the final review, deals with injuries to peripheral arteries in an equally authoritative and comprehensive way. He has not such a happy role to fill, because surgical progress in this field has been less striking; he has to record that the results of primary ligation of main arteries are still unsatisfactory and that arterial restoration by grafting remains uncertain in spite of many brilliant attempts and a few outstanding successes.—Philip Wiles

A PRACTICE OF ORTHOPAEDIC SURGERY. By T. P. McMurray, C.B.E., M.B., M.Ch., F.R.C.S. (Edin.), Professor of Orthopaedic Surgery, Liverpool University; Honorary Orthopaedic Surgeon, David Lewis Northern Hospital; Director of Orthopaedics, Royal Liverpool Children's Hospital. Third edition. $8\frac{1}{2}\times 6$ in. Pp. viii+444, with 191 figures. Index. 1949. London: Edward Arnold & Co. Price 30/-.

It is scarcely fitting to carp about a book that is twenty-one years old and has survived six printings, yet to the reviewer this book is showing its age. The principles of orthopaedics may not change—and, as might be expected from a disciple of Robert Jones, they are here clearly stated—nevertheless treatment changes, sometimes because of increased knowledge and sometimes at the whim of fashion. Dare one say that the present edition has not followed these changes closely? Royle's operation, Whitman's reconstruction of the hip, and enucleation of the tarsal bones for club foot might be omitted. The chapter on acute osteomyelitis needs complete reconstruction because of the discovery of the antibiotics. In the treatment of infantile paralysis the shift of emphasis from rigid splintage has not been stressed. Since in orthopaedics early diagnosis is so important, it is a pity that tuberculosis of the spine is illustrated by a child with gross kyphosis; tuberculosis of the spine will not be discovered early until the practitioner is accustomed to notice the small break in the uniform curve of a child's spine in the bending position. Nor will a slipped epiphysis of the upper end of the femur be picked up early if he expects a history of injury. It is strange to find from Liverpool operation recommended as the only treatment for a ruptured intervertebral disc. Certain ommissions strike one: references to senile osteoporosis of the spine and stenosing tendovaginitis would be welcome. Claw toes might well be considered apart from pes cavus.

Although the production, we are told, is of war economy standard, it could hardly be better. Most of the radiographic reproductions are so good that an occasional obscure picture is noticeable: the picture of spondylolisthesis is nothing but a blur. Publishers should realise that bad illustrations are worse than useless. This book is such an old favourite of this reviewer that he would wish the next edition to be perfect.—George Perkins

TUBERCULOSIS OF THE KNEE JOINT: AN EXPOSITION WITH SPECIAL REFERENCE TO COURSE AND TREATMENT BASED ON STUDIES OF THE LITERATURE AND ON AN ANALYSIS OF A MATERIAL OF PATIENTS OBSERVED THROUGH MANY YEARS. By Johannes Mortens. Translated from the Danish by Axel Andersen. $10\times 6\frac{3}{4}$ in. Pp. xiv+550, with 6 figures, 13 tables and 43 charts. 1948. Copenhagen: Einar Munksgaard. London: H. K. Lewis & Co. Ltd. Paper cover. Price 37/6.

Dr Mortens describes tuberculosis of the knee as it occurred in 118 patients treated at the coastal hospital at Refsnaes, Denmark, and in the surgical tuberculosis department of the Finsen Institute, to whose chief, Johannes Meyer, he pays tribute. These were patients in whom the diagnosis was not in doubt

He analyses the results of conservative and operative treatment in the light of follow-up examinations performed more than ten years later He compares these results with comparable results by other surgeons to obtain which he has submitted the literature on conservative treatment and operative treatment to exhaustive analysis He also gives a valuable history of the treatment of tuberculosis of the knee The much of the work consists of a mass of detail and it becomes a little difficult to see the wood for the trees But answers to certain questions emerge and these are so important and are so well authenticated that Dr Mortens s effort is amply rewarded

The questions that Dr Mortens sets out to answer are whether conservative treatment of the disease in children gives good results or whether excision is preferable in some If so what are the risks of shortening or deformity? About adults he discusses whether excision should be performed early or late By conservative treatment he means bed rest in an open-air hospital splintage (which seems to be less rigidly applied than here) and actinotherapy for which the Finsen Institute is famous and which is used to the full Sixty two children received conservative treatment only twenty recovered with a good range of movement and little damage to the joint seven others had a range of movement varying from 40 degrees up to 140 degrees thirteen got bony ankylosis, seventeen developed fibrous ankylosis, three patients died and in two the disease did not heal Of fifteen children who had resection after conservative treatment fourteen developed bony ankylosis three children who had primary resection did badly Dr Mortens goes on to discuss resection in childhood and finds that bony ankylosis can usually be obtained though it takes longer to develop than in the adult The lowest age limit set for excision is nine years Notable shortening did not often occur in cases in which there had been little destruction of cartilage or erosion of bone, but he found that it was common after excision of joints that had suffered gross destructive change Yet these are the joints for which excision may particularly be required, but there is less risk of shortening if excision is performed when the lesion is healing Dr Mortens would favour also excision if the disease is still active six or seven years after the onset He considers deformity after excision to be a more formidable complication than shortening To avoid deformity the limb must be fixed in full extension at operation Many patients must wear a splint for three or four years after operation and others must have a tenotomy of the flexor tendons It is clear that Dr Mortens has no enthusiasm for the treatment of tuberculosis of the knee in children by excision and from his research he finds no encouragement to depart from conservative treatment as a routine measure For adults on the other hand conservative treatment is recommended only if it does not interfere with their wage-earning capacity, excision is the method of treatment recommended if the general condition of the patient is satisfactory and the disease in the joint not very active

In the chapter on pathogenesis Dr Mortens retains the distinction between a primarily osseous and primarily synovial type of lesion but admits that the disease is present in both bone and synovial membrane as soon as it becomes recognisable The joint lesion is regarded as part of a haematogenous infection in which tubercle bacilli are deposited in the latent form in various parts of the body, and the development of overt lesions is governed by circumstances that determine tissue resistance Associated pulmonary tuberculosis was especially common

There is much else in this book that repays study There are questions to ask Dr Mortens for example whether constitutional treatment can safely be curtailed in adults, in whom the incidence of associated lesions is so high and whether the prognosis for associated pulmonary tuberculosis is improved by operation into a tuberculous joint There can be no doubt about the merit of this outstanding contribution to the literature of skeletal tuberculosis —M C WILKINSON

OSTEOPATHIE RARE By C CASUCCIO Libero docente di Clinica Ortopedica nell Università di Bologna Primo aiuto dell Istituto Ortopedico Rizzoli Prefazione di F Delitala 10×7½ in Pp xii+545 with 292 figures Index 1949 Bologna Edizioni Scientifiche Instituto Rizzoli Price 5500 Lira

This exhaustive study of the rarer diseases of bone excluding infections and neoplasms is based on the vast material provided by the Institute Rizzoli and a very wide study of the relevant literature in all languages Like Ludin Casuccio classifies the diseases as either atrophic or hypertrophic and sclerotic This method has considerable disadvantages, but none will be satisfactory until more is known of the etiology and pathology of these conditions There is some lack of balance in the amount of space given to the description of various diseases For example the epiphysial changes in cretins receive but brief mention while eosinophil granuloma occupies nineteen pages excellently illustrated and documented Again some of the chapters contain a conglomeration of conditions which in this country might not all be considered closely related The radiographs and histological plates are excellent and together with the description present a clear picture of the conditions and what is known of their etiology pathology course and treatment This book is a mine of information and provides knowledge that could otherwise be obtained only with great difficulty from original sources in many languages The style is clear and the Italian intelligible to the reader with the slightest knowledge of the language The bibliography is comprehensive

excellent and exceptional in that the full title of the original article is mentioned This is a valuable and unique book of reference on an important but complex subject —V H ELLIS

This monograph is based on a comprehensive study of the uncommon skeletal affections included in the great collection of documented material now available in the Rizzoli Institute A wide search of the literature has also been carried out and the ample bibliography shows that full recognition has been paid to the contributions of others on this subject The work bears the imprint of the famous Bologna School of Orthopaedics The author has adopted the convenient method of classifying skeletal disease under two main categories 1) atrophic lesions (osteoporotic osteolytic and dystrophic), 2) hypertrophic lesions (hyperostotic osteosclerotic osteoplastic) Each skeletal disease is presented in clear and simple language with the clinical radiographic and histological features described in proper perspective The format of the volume is admirable The author is to be commended for producing a work of reference which all orthopaedic surgeons will find of the greatest assistance —Harry PLATT

AN ATLAS OF TRAUMATIC SURGERY By Josep TRUETA, M D, Barcelona D Sc (Hon) Oxon, F R C S (Hon) Canada Surgeon Wingfield-Morris Orthopaedic Hospital, Oxford 10×8 in Pp xiii+150, with 188 figures 1949 Oxford Blackwell Scientific Publications, Ltd Price 30/-

The development of the closed plaster technique in the treatment of open injuries is closely associated with the name of Trueta Like many other orthopaedic surgeons who were impressed by the work of Baer and of Winnett Orr in the later part of the First World War he introduced the technique into his civilian practice and then, in the Spanish War of 1936–38 he was able to apply it on a big scale to the treatment of war wounds The results he achieved were outstanding and the publication of his book Treatment of War Wounds and Fractures ' at a most opportune moment in 1939 was followed by the general adoption of the ideas he had so ably advocated In the recent war as a member of the surgical staff of the Wingfield-Morris Orthopaedic Hospital Oxford he was able to continue working along the same lines and his present book is the record of an achievement no less remarkable than the first An Atlas of Traumatic Surgery is a straightforward narrative and pictorial record of the progress and treatment of forty patients with compound fractures and large wounds of the upper and lower limbs chosen from 127 serious casualties treated since the day of the landing in Normandy As the hospital included a peripheral nerve centre most of the injuries were complicated by peripheral nerve injuries No attempt is made to describe details of technique and the text consists of unvarnished extracts from the hospital records the reader is therefore free to form his own conclusions and he cannot fail to be impressed by the magnificent results that were regularly achieved The book however is not only a record it is also a challenge for the author states in his preface It is primarily to meet the need of these future workers [of a new generation] that this book is published although it is hoped that it may be of interest even now as a record of clinical experience by providing material for comparison of results for those still facing similar problems ' The difficulty of judging honestly the results in the treatment of major injuries is notorious and it is impossible to set the performance of one surgeon against that of another because the precise conditions can never be known It is however noticeable that although treatment was carried out at a time when delayed primary and secondary suture were in common use they were performed on a minority of the larger wounds in this series It is also apparent that re-excision of wounds was frequently required—it may be because the primary forward surgery was for some reason below the usual standard But even should some other surgeon claim better or quicker results this would in no way detract from Trueta s achievement He has done fine work and given us a magnificent permanent record of it a record of lives saved and desperately mangled limbs restored to useful function and any surgeon of the present or a future generation should be proud if he can do as well —Philip WILES

FIG 139
Condition of the wound and fracture on admission twenty-five days after injury The great muscular loss makes it very difficult to maintain the fragments in correct position

FIG 144
Almost two years after injury the condition of the limb is knee flexion 80 degrees One year later is 105 degrees

PLASTER OF PARIS TECHNIC By Edwin O GECKELER, M D Professor of Orthopaedic Surgery and Chief of the Fracture Service Hahnemann Medical College and Hospital, Philadelphia Second edition 9×6 in Pp xiv+220, with 236 figures Index 1948 London Bailliere, Tindall & Cox Price 16/6

This book has already been reviewed briefly in an American number of the Journal but without critical comment The teaching of plaster technique requires very orderly instruction Here however elementary and advanced details alternate, and the numerous illustrations lack continuity Some of the techniques described must lead to trouble or complaint Thus, few surgeons would agree with the following captions ' If the ankle has been immobilised in equinus by mistake a rectangular window will permit a change in the position without pinching the skin ' ' Short hip spica the back view shows the buttock on the affected side completely covered with plaster " " Application of plaster jacket (two table method no padding is necessary ' ' Certain conditions of the knee, as separations of the lower femoral epiphysis require immobilisation in hyperflexion ' To continue in this vein, the cast shown for a mallet finger completely straight at the proximal joint flat-foot deformity is treated by inversion of the whole foot and a plaster figure-of-eight is used for fractures of the clavicle in children In short, it may be fairly said that many of the techniques advocated show a wide variation from good contemporary practice in this country —K I NISSEN

FRACTURES AND DISLOCATIONS FOR PRACTITIONERS By Edwin O GECKELER M D Fellow of the American College of Surgeons Fellow of the American Academy of Orthopaedic Surgeons Fellow of the American Association for the Surgery of Trauma Diplomate of the American Board of Orthopaedic Surgery Fourth edition $9\frac{1}{2}\times6\frac{1}{2}$ in Pp xii+371, with 344 figures Index 1948 London Bailliere Tindall & Cox Price 27/6

The object of this book is to provide a simplified yet practical account of the treatment of fractures and dislocations for general practitioners and senior students This is no easy task, and the author has approached it with a due sense of realism and responsibility He devotes a good deal of space to fundamental principles and fundamental techniques, and, in dealing with individual fractures for which a variety of treatments has been advocated, he confines his advice to one method which in his experience has proved to be the ' simplest and most reliable for the best functional result "—a most refreshing reaction from the present tendency to dispute the right of any patient to be cured without a display of surgical virtuosity But there is also danger in over-simplification, this Dr Geckeler avoids by indicating quite clearly the conditions in which complicated and difficult techniques are indispensable Here he is at pains to tell readers how to handle such cases until more skilful help can be obtained The key-note of his advice in such circumstances is ' If there is doubt as to the treatment of a difficult case, it is far better to call a consultant at once than to meddle and manipulate repeatedly "

In matters of detail there is room here and there for criticism Volkmann's ischaemic contracture is *not* due to venous obstruction In adults half an inch of shortening does *not* usually cause a permanent limp Distraction should be added to the important causes of delayed union Total division of the spinal cord does *not* lead to a fatal issue ' regardless of the best care " (there are eight paraplegia centres in the author's own country proving the exact opposite) The removal of ununited transverse processes is an operation strongly to be condemned and not easy to perform—whereas open reduction of fractures of both bones of the forearm which the author condemns is widely practised, with good results even in the comparatively conservative atmosphere of Great Britain Finally most surgeons will be unnecessarily alarmed to read that in one out of every three dislocated hips the femoral head undergoes avascular necrosis

The author has a clear direct style and the text is well illustrated A short bibliography concludes each chapter but with few references to the literature of the last five years —E A NICOLL

SURGERY ORTHODOX AND HETERODOX By Sir William Heneage OGILVIE K B E D M M C F R C S, Hon F A C S Hon F R C S (Canada) Hon F R A C S Surgeon Guy s Hospital and Royal Masonic Hospital 9×6 in Pp v+241 with 30 figures 1948 Oxford Blackwell Scientific Publications Price 12/6

In this volume Ogilvie has collected a number of lectures and addresses on surgical topics T... reveal the thoughts of an elder statesman which if not profound, could not be more delightfully expressed The music of the words reminded the reviewer of the many occasions he has sat enchanted listening to the oratory of the author —George PERKINS

ATLAS OF NEUROPATHOLOGY By Wm BLACKWOOD, M B, F R C S E, Assistant Pathologist, National Hospital Queen Square, formerly Senior Lecturer in Neuropathology Edinburgh University T C DODDS F I M L T, F I B P F R P S, Laboratory Supervisor, Department of Pathology Edinburgh University and J C SOMMERVILLE, A I M L T, Senior Technician Department of Neuropathology, Edinburgh University Foreword by Professor A Murray Drennan M D, F R C P E, F R S E 10×7½ in Pp xi+199 with 262 figures, 30 in colour Index 1949 Edinburgh E & S Livingstone Ltd Price 35/-

In recent years the Edinburgh School of Medicine, ably assisted by the publishing house of E & S Livingstone has distinguished itself by the publication of a number of atlases in which the choice of subject and the execution of the illustrations are noteworthy The present volume is a worthy addition to the series As Professor Drennan writes in the foreword, it represents the " combined effort of the pathologist who identifies and selects the lesion, the technician who makes possible its detailed study and the artist who perpetuates it for all to see ' As in research, advance in teaching methods is thus fostered

FIG 43

Cerebral artery showing a mycotic aneurysm The organisms in the infected embolus can be seen as a bluish haze at the periphery of the embolus The arterial wall is weakened and bulging (upwards and to the right) and there has evidently been some leakage of blood (haemalum and eosin, ×80)

FIG 54

Cerebral cortex in a case of meningococcal leptomeningitis The surface is very congested and the creamy coloured purulent exudate is most abundant in the regions where the subarachnoid space is large *e g* along the sulci (as shown), in the basal cisterns and around the cauda equina A large vein runs across the field

The authors begin with illustrations of the normal histological structure of the central nervous system, and in a series of ten chapters progress through Vascular Disease Infections, Demyelinisations Intoxications Degenerations Trauma Hydrocephalus, Tumours and Errors in Development " The purpose of the atlas is to try to present to clinicians or pathologists beginning the study of neuropathology the most important pathological conditions in a clear and simple way Towards this end the authors have been uniformly successful In each of the chapters there are illustrations of the common pathological conditions The naked eye lesion as the student or pathologist sees it is illustrated first Then, in a series of well-chosen and competently executed photographs the general features of the pathological process are made clear Each illustration is accompanied by a descriptive legend, and in addition there is sufficient matter in the text to assist the beginner to an understanding of the disease In many instances the illustrations are accompanied by a brief clinical history of the patient from whom the pathological specimen was obtained

It is obvious that the value of such an atlas depends upon the choice of subject material and the quality of the illustrations The authors have chosen wisely The quality of the illustrations is in general excellent A few of those in colour are not quite faithfully reproduced The occasional diagram and drawing still further help the student to obtain a clear picture of the disease process This atlas will be a useful companion to the young pathologist embarking on the study of neuropathology To the clinician who takes an interest in the disease process it will be a valuable visual aid Authors and publishers are to be congratulated upon the production of a book which is not one to borrow but to buy —J Henry BIGGART

DEMONSTRATIONS OF PHYSICAL SIGNS IN CLINICAL SURGERY By Hamilton Bailey, F.R.C.S. (Eng.), F.A.C.S., F.I.C.S., F.R.S.E. Surgeon, and Surgeon-in-charge of the Genito-urinary Department, Royal Northern Hospital, London; Senior Surgeon, St Vincent's Clinic and the Italian Hospital; Surgeon, Consolation Hospital, Lambeth; General Surgeon, Metropolitan Ear, Nose and Throat Hospital, London. Eleventh edition. In four parts, Parts II, III and IV. $8\frac{1}{2}\times 5\frac{1}{2}$ in. Pp. 101–426, with 657 figures, many in colour. Index. 1948. Bristol: John Wright & Sons, Ltd. Price 8/6 each part. Paper cover.

In August 1948 we reviewed the first part of "Demonstrations of Physical Signs in Clinical Surgery," and now the remaining three parts have been published, of which the fourth is of most interest to orthopaedic surgeons in so far as it includes examination of the major joints, the peripheral nerves and the peripheral blood-vessels. The succinct text and the many telling illustrations are noteworthy. There is probably no surgeon who would fail to benefit from reading this work. For the postgraduate student this book is particularly helpful. He might perhaps find an easier discipline in a more systematic approach, particularly, for example, in the examination of joints. This is certainly true of the undergraduate who would be sadly misled by such a statement as 'mensuration is the first step in the examination of the hip.'

There are some shortcomings in the clinical pictures. In a description of sciatica, physical signs in the lumbar region are omitted altogether; in considering derangements of the knee joint a torn medial ligament is described as common, whereas a strain is not mentioned; calcaneal spur is regarded as a source of pain distinct from plantar fasciitis and with a different site of tenderness; neurosis is implied to be the only cause of glove or stocking anaesthesia; and there are further examples. On the other hand, we welcome the common sense of such quotations as, "No orthopaedic surgeon draws Bryant's triangle. It suffices to kneel facing the patient and to put the thumbs on his anterior superior iliac spines, the middle fingers on the tips of the great trochanters and the ring and little fingers behind the great trochanters. Slight differences in the height of the trochanters are detected easily in this rapid way" (Alan Todd). We applaud the measurement of shortening by making the patient stand on wood blocks instead of making estimates with a tape-measure. The authors of signs and symptoms are quoted freely, and invariably their names are given in footnotes with an account of their principal appointments together with the dates of birth and death of those no longer living. It would be even better if each name could be followed by a reference to the classical description of the eponymous observation.—H. Jackson Burrows.

PHYSICS AND THE SURGEON By H. S. Souttar, D.M., M.Ch. (Oxon.), F.R.C.S. (Eng.), Hon. M.Ch. Trinity College Dublin, Hon. F.R.A.C.S. Consulting Surgeon, London Hospital. $8\frac{1}{2}\times 5\frac{1}{2}$ in. Pp. vii+ , with 41 figures. 1948. Oxford: Blackwell Scientific Publications Ltd. Price 7/6. (This volume will be No. 48 of the American Lecture Series.)

This neat slim book is full of interest though its few pages cannot hope to cover a very wide field, especially when over half are devoted to atomic physics. The mechanical principles of perennial interest to orthopaedic surgeons are illustrated by a number of line drawings, several of which, however, are hardly worthy of the text. For instance, in one figure the terminal phalanx appears to fuse with the nail, while the portly outlines of an oarsman are unflattering to British sportsmen, and make one inclined to doubt the magnitude of the forces developed in rowing. Abduction of the arm is described as taking place entirely at the shoulder till the right angle is reached, whereas it is now generally recognised that there is a gradual transition to scapulo-thoracic movement almost throughout this range. The account of atomic physics is clear and fascinating.—K. I. Nissen.

ANATOMY AND BALLET By Celia Sparger, M.C.S.P., C.C.P.E. Consulting Physiotherapist to the Sadlers Wells School. Foreword by S. L. Higgs, F.R.C.S. Orthopaedic Surgeon, St Bartholomew's Hospital. Introduction by Ninette de Valois, C.B.E. $9\frac{3}{4}\times 7\frac{1}{4}$ in. Pp. 77, with 43 figures. 1949. London: A. & C. Black Ltd. Price 12/6.

This book on Anatomy is written for teachers of Ballet. The orthopaedic surgeon will be surprised to read that the function of the infrapatellar fat pads is to prevent friction between the patella and tibia. But he will find much to interest him in the radiographs of hip and ankle joints taken in various dancing positions, and in considering the relationship to ballet of hallux valgus, internal derangement of the knee joint and postural deformities of the spine.—R. Watson-Jones.

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The Journal of Bone and Joint Surgery

BRITISH VOLUME

EDITORIALS

BREVITY IN SCIENTIFIC CONTRIBUTION

No one likes a bore. In our speech we take care to avoid it but in our writing we are not so particular. We forget that "the ablest physicians, whose attention all writers want most to attract, are in the habit of quickly skimming through large numbers of articles always looking for one thing, and that is something new, significant, important and usable."[1]

After an article has been written it should be put away in a drawer and forgotten. On reading it again the writer will be appalled by the obscurity of his language and his verbosity. Unless he be one in a thousand—in which case he has missed his vocation—he will find that he must often read a sentence a second time before he knows what it says, and then translate it into simpler terms before he can grasp its meaning. "There probably never was a good paper which was not worked over several or many times. The writer will do well to search through his pages for every sentence and word that can be deleted without taking from the essential message. Every sentence that is vague should be rewritten until it can have but one meaning and that an obvious one."[1]

Let no one be afraid of short sentences and short words. Would the ten commandments be more explicit, or more expressive, if they were expanded to twice the number of words? "Say it with flowers" does not apply to the writing of scientific articles. Leave it to the politicians to say that *the answer is in the negative* and be content with *no*.

Every article is improved by being shortened. All editors are agreed on this but such human nature that no author can believe it about his own paper. Not a paper is published n this Journal that has not been submitted to the editor's blue pencil. What is cut out? irst, unnecessary words—and how many there are; second, airy suppositions unsupported y evidence—and how frequent they are; third, inconsequences—and how ubiquitous they re; and fourth, long introductions—and how tedious they are.

History is all very well in its place, but few readers are interested in what Hippocrates r Celsius wrote; those who are had better consult Bick. If you must refer to the literature, o it as briefly as you can. In these days the reader, at least the British reader, wants meat; o not dawdle over the soup. "The ablest writers try at the start to so grip the interest of e reader that he will want to go on."[1]

Illustrations are meant to illustrate. They should make clear what has been said, or onvey to the reader something that cannot be conveyed by words. Every illustration should ave a purpose; it is not inserted for its beauty, it must earn its place. An amusing occupation to look through any article in any Journal and count the worthless illustrations.

One remark on grammar. A sentence is entitled to subject and verb but many would-be ntributors deny it the one or the other. Note again the first sentence of this paragraph.

Allow me to give one final word of advice. Before submitting a paper to this Journal y publication, buy Fowler's *Modern English Usage* and paste in it a copy of the article by Alvarez from which we have quoted freely. The editor will get to bed earlier, his temper l be sweeter, and his blue pencil will last longer. You yourself will rise in the estimation your readers.

GEORGE PERKINS

[1] ALVAREZ, I. (1949): Proceedings of Staff Meetings of the Mayo Clinic, August 17, 1949.

THE HAND AND FOREARM

Most of the advances in the surgery of the hand are being made by comparatively young surgeons, none of whom would fail to acknowledge the stimulus derived from the mature work of Bunnell. Nevertheless, of the spontaneous writings collected in this number into a "symposium," few deal with the surgery of repair, and their variety illustrates the catholicity of the interests in this confined anatomical field.

The first fifteen articles have fallen into a natural sequence. First comes a report on infections of the fingers by the staphylococcus, and everyone agrees on the urgent need for garrotting this invader before it learns to counter every antibiotic weapon we possess. Next comes a disturbing review of the variable distribution of the median and ulnar nerves in the hand, disturbing at least to those who rely on a few simple tests for the integrity of these nerves. Its companion article deals with the "bail-graft" for the *main-en-singe* deformity of thenar paralysis. Then come four papers, paired like theorem and corollary, on the semilunar bone and the carpus. The next group of articles deals very completely with osteoarthritis of the trapezio-metacarpal joint: first the radiology, then the treatment by external splintage, arthroplasty or arthrodesis, and finally the congenital defects of the region. Strangely enough there is hardly a mention of Bennett's fracture-dislocation in these four papers.

From the small numbers of clinical studies we jump to the large numbers of anthropometry yielding evidence by strict statistical analysis. The present study of extension of the thumb may give results of great interest when it is extended downwards to the great toe: it is possible that Roberts' observation, that patients with hallux rigidus also have limitation of extension of the thumbs, may then gain statistical support.

The contribution on fractures of the scaphoid may remind some readers of the waning enthusiasm for bone grafting. Would it not be possible to trace a number of the many service cases so treated five or more years ago? Until this is done the prevalent subdued damnation of bone grafting, whether for reasons of expediency or for permanent benefit, must remain subdued.

The report on Leri's pleonosteosis points the way to further investigation of two primary syndromes of obscure etiology, namely, bilateral carpal tunnel compression of the median nerves and Morton's metatarsalgia. It may be that in both these conditions the primary abnormality is in ligaments, which were clearly the cause of median neuritis in this patient with pleonosteosis. But few surgeons resecting the plantar digital nerve bother to define either the degenerate vascular bundle or the foramen through which it runs, and those who use a dorsal excision cannot do so.

The contribution on Monteggia fractures may lead to consolidation of a number of scattered observations on the effects of rotation strain in the upper limb. For the benefit of those who did not hear this convincing paper when it was read to the British Orthopaedic Association the text has been illustrated very freely.

K. I. Nissen

GIANT-CELL TUMOUR OF BONE

In a recent number of the Journal we published a symposium on giant-cell tumour or osteoclastoma of bone, representing the views of many British pathologists and clinicians. No reader having studied the contributions and editorials would have been sure that a final and agreed opinion had yet been reached, and it was with little surprise that we received a spirited reply from Dr Lichtenstein. His observations, and the no less vigorous comments of Professor Dorothy Russell of London, are published in the correspondence columns.

Editor

NATURAL HISTORY AND TREATMENT OF PULP SPACE INFECTION AND OSTEOMYELITIS OF THE TERMINAL PHALANX

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Infection of the pulp space occurs with much greater frequency than more serious infections of the palmar space or tendon sheaths, and it may cause prolonged incapacity. There is often residual disability due to stiffness of joints, fibrosis of the tactile pad, or "minor causalgia" with a cold, blue, shiny and stiffened finger, aching pain of a "deep cold" quality and tactile hyperpathia. These cases are obviously important from a social and organisational standpoint. Statistics prepared for us by Professor R. A. Lane show that of all claims made under the Workmen's Compensation Act approximately 2½ to 5 per cent. were for septic hand lesions. Our own analysis of 1,979 patients seen in 1947 with hand infections indicates that 22 per cent. were pulp space infections, whereas only two cases were infections of tendon sheaths and five were infections of the palmar space (Table I).

TABLE I

ANALYSIS OF 1,979 NEW PATIENTS ATTENDING THE SEPTIC HAND CLINIC DURING 1947

	Percentage
Pulp space infections	22
Paronychia (acute and chronic)	26
Phalangeal infections	10
Web space infections	11
Boils and carbuncles	4
Miscellaneous lesions: collar stud abscess, lymphangitis, burns, septic lacerations, indelible pencil injuries, etc.	27
	Cases
Tendon sheath infections	2
Palmar space infections	5
Erysipeloid of Rosenbach	5

PATHOLOGY

The micro-organism concerned is usually the staphylococcus aureus (coagulase positive), but how it enters the pulp space is not always clear. In no more than half the patients is there a history of injury. Minor injuries are often overlooked or forgotten, but it may be that the staphylococcus enters by way of sweat or sebaceous glands (Cole and Elman 1948). Recent studies of the carriage of staphylococcus aureus in the skin and nose suggest that the skin of the hand may often be contaminated from the nasal vestibule by direct hand to nose contact (Moss *et al.* 1948).

The inflammatory reaction causes cellulitis which at first is confined by the tough fibrous septa that break up the pulp space into tiny compartments and are tightly adherent to skin and periosteum. It causes pain which is described as "tight" or "prickling." At this stage the infection may resolve spontaneously, particularly when chemotherapy has been used, but the number of such abortive cases is unknown because many never come to hospital.

If resolution does not occur, the formation of an abscess is accompanied by "throbbing pain At first the abscess is sharply limited by the fibrous trabeculae and it may be situated in any part of the pulp space (Hardman 1937) Thereafter it may spread in one of three directions 1) through the periosteum into the terminal phalanx, or more seldom, around the side of the phalanx giving rise to an associated paronychia, 2) through the skin in front, 3) through the containing fibrous walls on its sides The tissues which have least resistance to increasing tension, and to the locally produced necrotoxins, are the skin and periosteum thus a superficial pulp abscess gives rise to a sinus in the skin, and a deep abscess destroys the periosteum and causes early osteomyelitis of the terminal phalanx By the time the fibrous septa give way and a "total" pulp space abscess develops, osteomyelitis is already well established, there may also be a skin sinus This conception is substantiated not only by clinical observation, which shows that a spontaneous skin sinus always overlies the localised pulp abscess, but also by radiographic examination, which demonstrates conclusively that the first evidence of erosion of the affected phalanx is directly opposite the abscess (Fig 1) Thus in distal pulp space infection osteomyelitis begins at the tip of the phalanx, in lateral pulp space infection it begins on the corresponding side

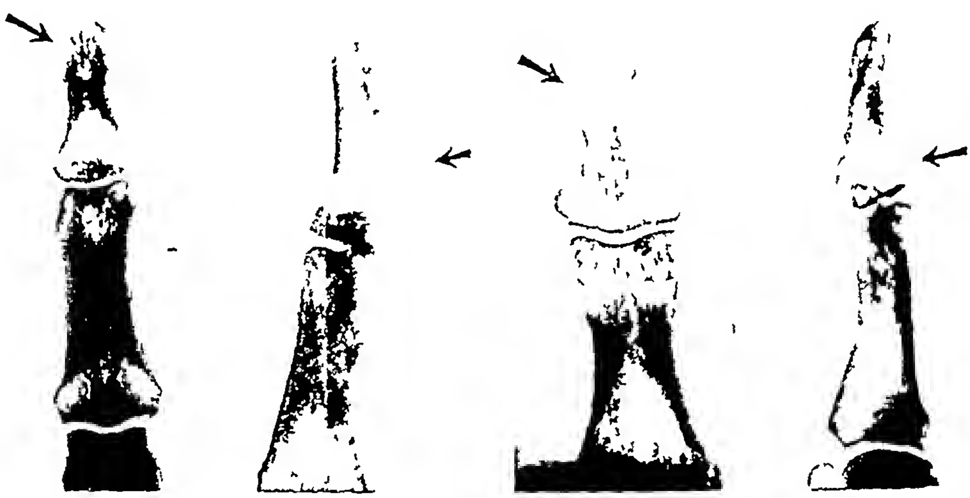

Fig 1
Four examples of pulp space infection showing that bone erosion is always directly opposite the soft tissue abscess

Hardman (1937) insisted that "the case must be treated before the onset of fluctuation for at this stage the phalanx is dead" Iselin (1940) recognised that a spontaneous skin sinus was often associated with underlying osteomyelitis This is always true if the abscess begins deeply in the space, but it is less constantly so in the case of more superficial lesions That "pulp space" infection is not at first a generalised infection of the pulp but a localised and sharply delineated abscess involving only part of the pulp area can be demonstrated clearly at operation The report of Iselin that "when incised it looks just like a boil with very little pus and ill-defined limits" is not in accord with our experience, such a description implies that the incision was made too early—that is to say, in the cellulitic stage

If left untreated, pulp space infection follows a course that depends essentially on the location of the abscess If it is superficial, a skin sinus develops before the periosteum or the fibrous walls are perforated, and by such drainage the infection may heal On the other hand deeper and especially more distal abscesses, where there is less soft-tissue buttress between the skin and periosteum, do *not* heal readily after the development of a sinus periosteal erosion has already occurred and the terminal phalanx is infected It is in these cases that disability is prolonged, and it is important to separate them clinically from uncomplicated felons because rapid healing can be achieved only by early and inter

penicillin therapy Once the phalanx is infected the rapidity of development of osteitis, beginning at a point immediately opposite the site of maximal abscess tension, seems to depend on the virulence of the invading organism (Bolton, Catchpole and Jepson 1947) In some patients particularly children, radiographic examination may show complete disappearance of the phalanx within a few days, in others bone erosion remains localised and the infection is quickly overcome In general, abscesses that are situated proximally and first infect the base or waist of the phalanx destroy the bone more quickly than distal abscesses

It is often said that occlusion or thrombosis of the digital arteries due to sustained compression in the inelastic pulp space by pressure of the abscess is an important cause of osteitis (Cole and Elman 1948), but we very much doubt whether this is true The clinical sign of local heat suggests that the blood supply is increased, and if the pulp is incised without a tourniquet there is always free bleeding If thrombosis were a common feature we should expect to find necrosis of the skin of the finger tip and ischaemic necrosis of the terminal

FIG 2

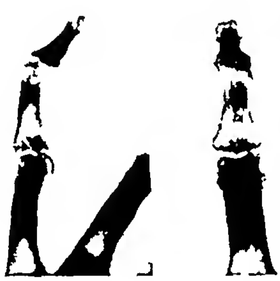

FIG 3

FIG 4

The only example in the series in which there was radiographic evidence of ischaemic necrosis of the terminal phalanx Radiographs on first attendance, six days after the onset of severe pulp space infection, showed no evidence of bone involvement (Fig 2) After ten days separation of a central slough exposed the necrotic terminal phalanx (Fig 4) Radiographs showed relative density indicating avascular necrosis of the whole terminal phalanx (Fig 3)

phalanx, radiography would show apparent density of the bone and not diffuse porosis or subtotal necrosis In our study of 300 patients with pulp space infection such changes were seen in only one case (Figs 2–4)

The degree of phalangeal reformation that may occur depends upon the extent of the bone lesion and the age of the patient (Fig 5) When there has been complete destruction of the phalanx and its periosteum no regeneration can occur, but when destruction is less complete the whole phalanx may regenerate in young patients, though less complete replacement is to be expected in adults

Occasionally infective arthritis of the terminal interphalangeal joint may develop by direct spread from a proximal abscess or from an area of osteitis The flexor tendon sheath extends almost to the middle of the terminal phalanx and it may become infected in pulp space infections by the injudicious use of lateral drainage incisions, but we have not seen any case of tenosynovitis arising spontaneously Probably the synovial sheath is obliterated by inflammatory reaction before bacterial invasion can occur

TREATMENT

From the point of view of treatment, pulp space infections may be divided into three clinical groups: 1) simple felon; 2) suspected bony felon; 3) established bony felon (Bolton, Catchpole and Jepson 1947). *Simple felon* is a pulp space infection limited to the soft tissues; with correct treatment it heals without complication. *Suspected bony felon* is one in which it seems probable that there is osteitis because there is persistent sinus formation, continued pain, massive sloughing, or evidence at operation of periosteal damage, and yet radiographic confirmation is lacking. *Established bony felon* is one in which there is definite radiographic evidence of bone infection.

The conservative measures that are sometimes advocated can have little application to the treatment of patients who almost invariably have complained of pain for not less than four days before their first attendance at the clinic. In every case in this series without exception pus was found in the pulp space when it was explored. The correct treatment for infection of the pulp space is incision and we believe that the only question to be determined is which incision is the best. For some time we have been dissatisfied with the lateral incisions that are used so generally. It is often found that a central pulp space abscess which has been opened widely by a J-shaped lateral incision, or bilateral straight incisions, continues to discharge through the overlying sinus, while the extensive lateral incisions close up and heal without serving any useful purpose after the initial evacuation of pus at the time of operation.

FIG. 5

Serial radiographs taken at four-week intervals in a child with pulp space infection showing regeneration of the phalanx.

Study of the pathology of these lesions indicates that a *local* abscess should be drained through the skin immediately overlying it rather than by means of oblique incisions which traverse uninfected pulp tissue and are quickly narrowed by oedema. Moreover it is evident that "minor causalgia," which gives rise to lasting incapacity in about 2 per cent. of pulp space infections, is due to injury to the digital nerve caused by a lateral incision. Anatomical studies make it clear that with lateral incisions it is largely a matter of chance as to whether or not the digital nerve will be severed. On the other hand small incisions placed directly over the abscess will not damage the nerves which are displaced laterally.

Certain points in the technique are important. The site of greatest tension and tenderness should first be localised with precision by palpation with a blunt probe. Localisation is made easy if there is a spontaneous sinus because the sinus always lies directly over the abscess cavity (Fig. 6). Sometimes pus has extruded only through the true skin, lying imprisoned beneath unbroken squamous epithelium and thus forming a collar-stud abscess. General anaesthesia and a pneumatic tourniquet by which to secure a bloodless field are essential if the abscess is to be localised accurately. A small ellipse of cornified epithelium overlying the abscess is first excised (Fig. 7). The small sinus, which can then so often be demonstrated in the true skin, is excised elliptically over a length of four to five millimetres, the axis being transverse for central abscesses and longitudinal for lateral abscesses. The circum-

Fig 6

Fig 7

Fig 8

Fig 9

Central pulp space infection with threatened sinus formation (Fig 6) An ellipse of skin was excised directly over the abscess which was traced down to intact periosteum (Figs 7 and 8) One week later the incision was healed (Fig 9)

abscess cavity, seldom measuring more than a few millimetres in diameter, is then revealed (Fig 8) The cavity is filled with penicillin in lactose powder No drainage is required because the cavity lies " saucerised " to the surface The wound is dressed with broad-mesh vaseline gauze and an outer layer of dry gauze In uncomplicated lesions two or three similar dressings at three-day intervals will suffice The cavity quickly collapses and the incision heals in not more than ten or twelve days (Fig 9) The scar is small and inconspicuous and the pulp is functionally unimpaired Immobilisation of the digit is very occasionally needed because there is infective arthritis of an interphalangeal joint, or the whole limb may need to be immobilised because of lymphadenitis, but in all other cases active movements are encouraged at once

RESULTS

Fifty unselected cases of pulp space infection have been studied In every patient an abscess was found at operation, the situation being either superficial, deep, lateral or central The results are shown in Table II The healing time was calculated from the day of first attendance to the day of discharge from the clinic with a healed wound The incidence in men and women was approximately the same The thumb and index finger were the digits most commonly affected Twenty-six patients attributed the lesion to a cut or injury When bone infection was suspected or proved, penicillin was given intramuscularly in doses of

TABLE II

	Number of cases	Previous incisions	Site of pulp abscess				Average healing time
			Superficial	Deep	Lateral	Central	
Simple felon	39	1	11	28	14	25	11 5 days
Suspected bony felon *	5	3		5	1	4	25 days
Established bony felon *	6	5		6		6	35 days

* Also treated by intramuscular injections of penicillin

100 000 units twice daily for ten to fourteen days, in most of these patients there was some limitation of movement of the terminal interphalangeal joint at the time of discharge from the clinic Only five patients in the whole series of fifty complained of a tender scar during the first few weeks after healing, and none developed causalgia

DISCUSSION

In the management of pulp space infections it is first necessary to decide whether or not an incision is required Some authors advocate "conservative" or "non-incisional" treatment of pulp space infections It may be that their patients have been seen at an unusually early stage of the disease, before pus was localised, but for our part we would restate that every one of the fifty cases in this series had at the time of incision a localised collection of pus which clearly demanded evacuation The second problem is to determine the best incision We have abandoned lateral J incisions and bilateral linear incisions because they traverse uninfected tissue fail to maintain drainage of the abscess, and may cause injury to the digital nerves with resulting causalgia A small incision accurately localised over the site of the abscess accelerates the time of healing, minimises pain, oedema and discharge, avoids injury to the digital nerves and does not cause persisting tenderness even when the scar is in the tactile pad Several of our patients were typists and despite the use of a central incision they resumed work within three weeks

SUMMARY

The pathology of pulp space infection is discussed It is recommended that a direct incision which is localised precisely to the abscess site, even if the incision is in the tactile pad, is better than a lateral incision, which fails to maintain drainage, causes longer incapacity, and may injure the digital nerve and give rise to causalgia Fifty cases of pulp space infection in which a direct incision was used are reviewed

Our thanks are due for the help and interest of Professor A M Boyd in whose department this work was carried out to Dr Stewart Harrison for his suggestions to Professor R E Lane for statistics and to the Radiological Pathological and Photographic Departments for technical aid

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ANOMALOUS INNERVATION OF THE HAND MUSCLES

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According to the usual text-book descriptions the median nerve supplies the abductor pollicis, opponens pollicis, flexor pollicis brevis and the two lateral lumbricals, while the ulnar nerve supplies all the other muscles in the hand (Gray 1946, Cunningham 1931, Wood Jones 1941). Several articles published since about 1890, notably in the French and the German literature, have mentioned variations found in anatomical dissections. The articles are remarkably contradictory. For example, Spourgitis (1895) stated that ulnar innervation of flexor pollicis brevis was very unusual—he had found it only once in all his dissections, whereas Riche (1897) considered it to be constant. Brooks (1886) drew attention to the existence of two heads of flexor pollicis brevis and found that their nerve supply varied. In dissections of thirty cadavers, flexor pollicis brevis was supplied by the ulnar nerve alone in five and by the median nerve alone in five, in nineteen the superficial head was supplied by the median nerve and the deep head by the ulnar nerve, in one the ulnar nerve supplied all the thenar muscles. Hovelacque reviewed the literature in 1927. He quoted Froment (1847) as stating that the median nerve constantly gave a branch to adductor pollicis, but Frohse and Frankel (1908) found this in only 10 per cent., a figure with which Poirier (1901) agreed.

The first clinical study of the subject seems to be that by Highet (1943). In twenty patients with median nerve division, flexor pollicis brevis was paralysed in only four, in twenty-five with ulnar division only one showed any wasting of flexor pollicis brevis. The obvious explanation of these figures is dual innervation of this muscle. Highet's patients were the early ones in the Oxford series and are included in my analysis.

Murphey, Kirklin and Finlayson (1946) examined 698 ulnar nerve lesions and found that the first dorsal interosseous was innervated by the median nerve in four patients, in one of whom abductor digiti minimi was also supplied by the median. In all four patients the lesion was above the elbow, in two, blocking of the ulnar nerve at the wrist produced paralysis, suggesting an anastomosis from the median to the ulnar nerve in the forearm. In 551 median nerve injuries, opponens pollicis was found innervated by the ulnar nerve once only. These workers used exceptionally strict criteria for the activity of a given muscle, and in their large series there may have been other anomalous innervations which they did not accept.

Clinical material—I have studied the records of all the median and all the ulnar nerve lesions from Mr Seddon's clinic at both the Wingfield-Morris and the Royal National Orthopaedic Hospitals. There were 688 cases in the group, but many were unsuitable for inclusion in the analysis. The final number accepted was 226, namely 102 median and 124 ulnar nerve injuries. For a case to be accepted there had to be definite evidence of complete interruption of axonal continuity, either the nerve was seen to be divided at operation or, in certain lesions in continuity, direct electrical stimulation of the nerve exposed at operation failed to produce contraction in any muscle. Percutaneous stimulation was used to obtain corroborative but never absolute evidence of the distribution of a nerve. Incomplete lesions and lesions of both nerves were discarded. Throughout the series there has been a high standard of notation, but the statement "ulnar intrinsics paralysed" without any record of more detailed motor examination made it necessary for a few cases to be excluded. The findings in all the accepted cases may be regarded as accurate, for they were made by workers who were fully conversant with the pitfalls of clinical examination of individual muscles and with the trick movements described by Wood Jones (1919). The power of muscles was

assessed according to the Medical Research Council's 0–5 grading (1942) This system is reasonably accurate if there is one observer throughout, but some discrepancies occur, especially between 2 and 3, when assessments have been made by several clinicians Therefore in this analysis 0 and 1 are classified as paralysed, 2 and 3 as weak, and 4 and 5 as fully active

Apart from visual and electrical proof of injury to either nerve, additional evidence was obtained in some instances by means of blocking the intact nerve with procaine and then observing the resultant paralysis (Highet 1942) Unfortunately, this was not done in all patients with anomalous innervation owing to pressure of work at the time

TABLE I

102 Median Nerve Lesions

Number of patients	4	3	13	14	38	16	10	1	1	1	1
Abductor brevis											
Opponens pollicis											
Flexor brevis											
Adductor pollicis											
	Fig 4				Fig 1	Fig 2	Fig 3				

Paralysed indicating median nerve supply

Weak indicating dual nerve supply

Fully active indicating ulnar nerve supply

TABLE II

124 Ulnar Nerve Lesions

Percentage	29	15	52	1	4	1
Number of patients	34	19	64	1	5	1
Abductor brevis						
Opponens pollicis						
Flexor brevis						
Adductor pollicis						
	Fig 1	Fig 2	Fig 3		Fig 5	

Fully active indicating median nerve supply

Weak indicating dual nerve supply

Paralysed indicating ulnar nerve supply

Only the median and the ulnar nerves have been considered There has been no certain evidence of innervation of any thenar muscles by the musculo-cutaneous or the radial nerve (Foerster 1929), although in one or two instances it was just possible In this series, therefore, if after division of the median nerve a muscle in the hand was fully active, it was considered to be supplied by the ulnar nerve, if active but weak, it was considered to have had a dual innervation, if paralysed, it was of course supplied by the median nerve No attempt has been made to differentiate between the two heads of flexor pollicis brevis, because clinically it is one muscle The lumbricals have been ignored owing to the difficulty of testing them accurately

Note—In all the figures and tables, colour indicates nerve supply and not voluntary power

Analysis of findings—Tables I and II show the possible combinations of nerve supply. It is seen that the text-book description is the commonest arrangement, abductor pollicis brevis, opponens pollicis and flexor pollicis brevis being supplied by the median nerve and the others by the ulnar nerve. There is an inconsistency in the figures, however, for flexor pollicis brevis remained active in most of the median (73 per cent.) as well as in most of the ulnar injuries (58 per cent.). This, of course, is explained by the fact that flexor pollicis brevis usually has a dual supply and loss of one component may leave its power not appreciably altered.

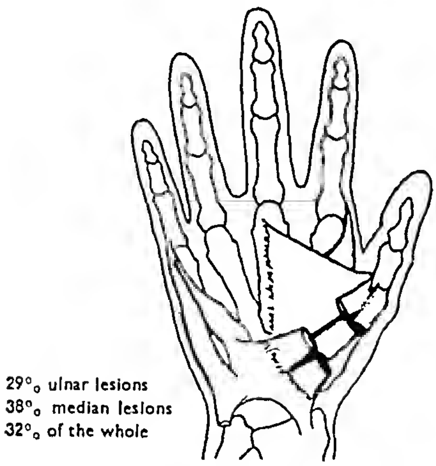

Fig. 1

The pattern of innervation in 32 per cent. of cases. The flexor brevis pollicis was supplied by the ulnar nerve. See column 5 of Table I and column 1 of Table II.

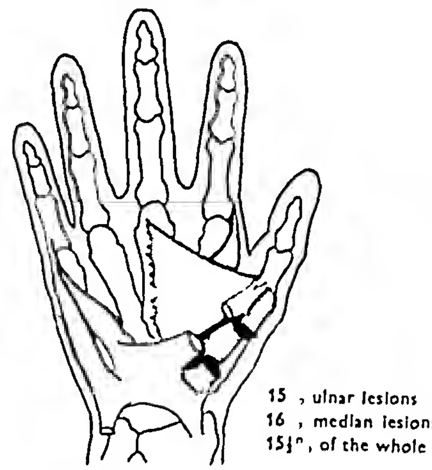

Fig. 2

The pattern of innervation in 15.5 per cent. of cases. The flexor brevis pollicis had a dual supply from both ulnar and median nerves. See column 6 of Table I and column 2 of Table II.

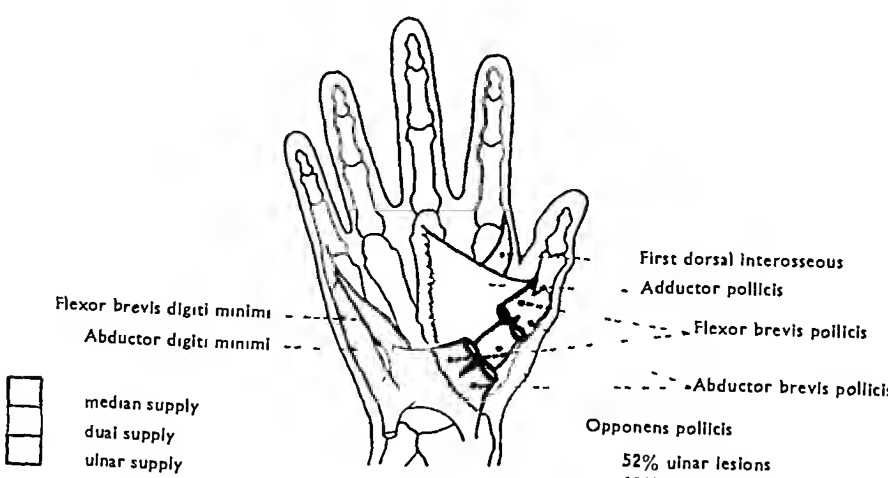

Fig. 3

The pattern of innervation in 33 per cent. of cases. The flexor brevis pollicis was supplied by the median nerve. See column 7 of Table I and column 3 of Table II. This is the standard text-book pattern.

Figures 1 to 3 show the common arrangements pictorially, with emphasis on the innervation of flexor pollicis brevis. Figure 1 shows the pattern in 29 per cent. of the ulnar lesions and in 38 per cent. of the median lesions, or in 32 per cent. of the whole. Figure 2 shows that there was clinical evidence of dual innervation of flexor pollicis brevis in 15 per cent. of the whole. Figure 3 represents the findings in 52 per cent. of the ulnar lesions and

ın 10 per cent of the medıan lesıons, or ın 33 per cent of the whole These three groups madı 80 per cent of the total

It ıs sıgnıficant that *one-fifth of all the cases studıed had an anomalous nerve supply of some kınd* On referrıng back to Tables I and II, ıt ıs seen that sıx cases had an unusual ınnervatıon of abductor pollıcıs brevıs alone Of these sıx, ın one (Table II, last column), we know that the ulnar nerve was responsıble, for abductor pollıcıs brevıs was paralysed after dıvısıon of thıs nerve In the other five, all medıan ınjurıes (Table I, columns 1 and 9), ıt ı not certaın why abductor pollıcıs brevıs remaıned actıve

Apart from these cases, there ıs every gradatıon from *complete ulnar* to *complete medıal* ınnervatıon of the hand Fıgure 4 shows one extreme ın whıch all the muscles receıved ulnar ınnervatıon Thıs occurred ın four patıents, all wıth medıan lesıons, to these may be added another three whose only motor loss was weakness of abductor pollıcıs brevıs Of the seven

TABLE III

SIX ULNAR NERVE LESIONS

NAME	LEVEL	DORSAL INTEROSSEI				PALMAR INTEROSSEI			HYPO-THENAR
		1	2	3	4	1	2	3	
De J	ELBOW					?	?	?	
D	ELBOW								
H	WRIST					?	?	?	
J	WRIST								
R	ELBOW								
T	ELBOW								

Fig 6

Fully actıve ındıcatıng medıan nerve supply

Weak ındıcatıng dual nerve supply

Paralysed ındıcatıng ulnar nerve supply

Table III Thıs table gıves further detaıls of sıx cases ın whıch the medıan supply exceeded that seen ın the common patterns of Fıgures 1 2 and 3 Fıve of the cases had the patterns shown ın Fıgures 5 and 6 whıle the sıxth, Case R had dual ınnervatıon of adductor pollıcıs

five had wrıst-level lesıons, ın one patıent procaıne block of the ulnar nerve at the elbow produced complete paralysıs of the hand In these five there can have been no motor branch of the medıan nerve ın the hand, except possıbly to abductor pollıcıs brevıs, and ın the or just mentıoned we know that there was no anastomosıs across to the ulnar nerve ın the forearm In the remaınıng two cases ın thıs group, the lesıons were near the elbow and r procaıne blocks were performed

At the other end of the scale we have medıan ınnervatıon of each of the four thumb muscles (Fıg 5), wıth medıan ınnervatıon of one or more ınterosseı ın addıtıon (Fıg There were five such cases, wıth a sıxth ın whıch there was dual ınnervatıon of adductor pollıcıs and of several ınterosseı (Case R)

Table III gıves further detaıls of these sıx cases It wıll be seen that only two of the ulnar lesıons were at the wrıst, the other four beıng at the elbow Case D had an ınjury

the ulnar nerve at the elbow but no paralysis of the hand muscles A median block at the elbow produced complete paralysis of the hand Percutaneous stimulation of the ulnar nerve at the wrist, however, produced strong contraction of all the *interossei* This suggested that the motor supply to the interossei travelled as far as the elbow in the median nerve and then

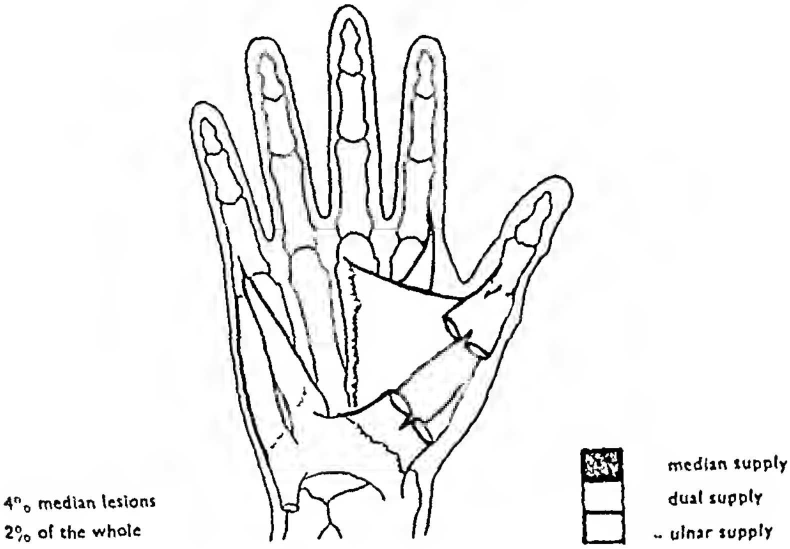

FIG 4

The pattern of innervation in 2 per cent of cases All the thenar muscles were supplied by the ulnar nerve See column 1 of Table I

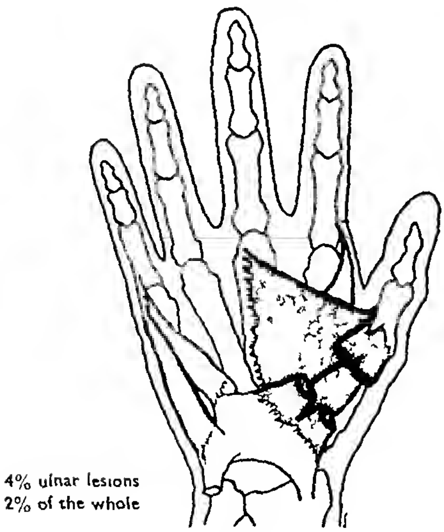

FIG 5

The pattern of innervation in 2 per cent of cases All the thenar muscles including adductor pollicis, were supplied by the median nerve See column 5 of Table II

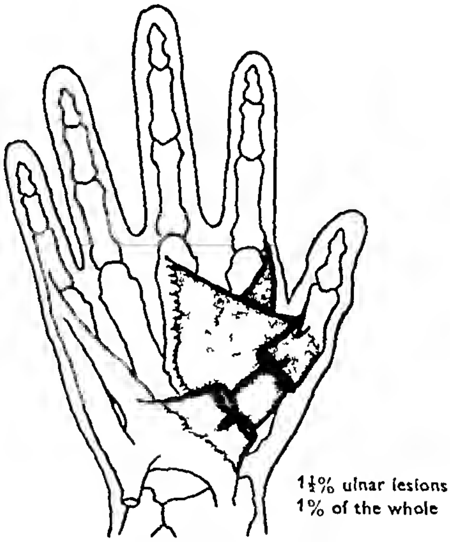

FIG 6

The pattern of innervation in 1 per cent of cases All thenar muscles including adductor pollicis and the first dorsal interosseous were supplied by the median nerve See column 1 of Table III, Cases de J and D

ssed over to the ulnar nerve in the forearm In Case H the converse obtained This patient had a low ulnar lesion, but electrical stimulation of the ulnar nerve at the elbow produced a good contraction in the hypothenar muscles, the first dorsal interosseous, the adductor pollicis and the palmar interossei, suggesting a free anastomosis from the ulnar to the median nerve in the forearm

CONCLUSIONS

1 Voluntary activity of any given muscle in the hand is not an absolute indication of the state of the nerve which usually supplies it

2 Significant variations in the standard pattern of innervation have been found in 20 per cent of 226 cases studied

3 The pattern of innervation described in standard text-books occurred in only 33 per cent of cases

4 A striking variation is the supply of every thenar muscle by the ulnar nerve In other cases the first dorsal interosseous muscle may be supplied by the median nerve

5 In order to arrive at an accurate diagnosis when anomalous innervation is suspected nerve blocks at appropriate levels are required

6 Great care must be taken during operations to avoid damage to connections between the ulnar and the median nerves, especially in patients with anomalous innervation of the hand muscles

I wish to pay tribute to all members past and present of the Peripheral Nerve Injury Units who have so accurately recorded their findings in the cases used in this analysis I thank Mr H J Seddon for all his help and encouragement and Miss Stanley for the drawings

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INTER-METACARPAL BONE GRAFT FOR THENAR PARALYSIS

Technique and End-results

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In 1930 Foerster described an operation for restoring opposition of the thumb in cases of paralysis of abductor brevis and opponens pollicis, a bone graft was inserted between the first two metacarpals to maintain the thumb in palmar abduction and opposition The method was elaborated by Thompson (1942) and the results in seven cases were reviewed Both authors were satisfied that the function of the hand was considerably improved The alternative operation of fusing the trapezio-metacarpal joint was tried by Stiles and Forrester-Brown (1922), but they found, as did Lyle (1926), that the grip between the thumb and index was weak That this is probably due to increased movement at the trapezio-carpal joint is substantiated by Muller (1949) who has found that a good range of movement of the thumb is retained after arthrodesis of the trapezio-metacarpal joint for osteoarthritis

This paper is based on a review of sixteen cases in which bone graft operations were performed for thenar paralysis from peripheral nerve lesions Some unexpected sequelae have been encountered and have led to certain modifications in technique

Indications for operation—The sole indication for an opponens bone graft is permanent paralysis of the abductor brevis and opponens pollicis muscles for which tendon transplantation to restore active opposition cannot be performed When flexor pollicis brevis and abductor pollicis *longus* are working strongly, control of the thumb is often good and no reconstructive operation is necessary As Highet (1943) and Rowntree (1949) have shown, flexor brevis is often supplied by the ulnar nerve and may therefore be spared even in complete median palsy

The employment of the tendon of flexor sublimis to the ring finger as a motor tendon for opposition of the thumb has become almost as reliable as tendon transplantation for radial palsy, flexor or extensor carpi ulnaris, though less satisfactory, can also be used (Bunnell 1948, Irwin 1942, Thompson 1922) A tendon for transplantation is not available when these three muscles are either paralysed or weak Lack of independent movement of muscles that have recovered after suture of a main nerve is a well-known phenomenon Thus, after high suture of the median nerve, even though flexor profundus and flexor sublimis digitorum may contract strongly together, there is loss of independent contraction of flexor sublimis—one of the special merits of this muscle Furthermore, scarring about the wrist may make tendon transplantation impossible Under such circumstances stabilisation of the first metacarpal bone in the best position is indicated

Just as in tendon transplantation, any fixed adduction contracture, particularly of the skin, should be overcome before bone-grafting If the deformity is secondary to shortening in the adductor pollicis muscle alone, it may be corrected either at operation or by means of preliminary stripping of the first metacarpal The preliminary stripping was done in cases where there seemed to be some prospect of recovery in abductor pollicis brevis, in a few cases power returned soon after the over-stretching of the abductor had been corrected and there was then no need to proceed to the grafting operation If the patient is in doubt about the benefit he will derive from the operation, trial plaster fixation of the thumb in the position of function will help him to make up his mind

THE OPERATION

A graft from the subcutaneous border of the ulna is inlaid as a strut between the first and second metacarpals so as to control abduction and rotation of the first metacarpal with the thumb in the optimal position A tibial graft was used on six occasions, but later the

ulna was found to be a better donor site and provided a graft of convenient size and shape which was used in a further nine cases A segment of rib was satisfactorily employed once

Technique—Two curved incisions are made over the first and second metacarpals so that the scars do not overlie the graft at any point (Fig 1A) The shafts of the metacarpals are exposed subperiosteally, and if there is any contracture of the adductor pollicis the muscle is divided at its insertion and full passive correction obtained The terminal part of the radial artery is not exposed deliberately nor indeed should it be seen A narrow osteotome is passed across the space deep to the first dorsal interosseous muscle so that it lies over the middle of the shaft of each bone, the thumb is then placed in full palmar abduction and the length of graft required is noted

The ulna is exposed subperiosteally through a three-inch vertical incision over the lower third of the subcutaneous border and a graft of the required length is cut with a motor saw This gives a piece of bone that is D-shaped in cross-section and rather more than a centimetre in width The incision is then closed

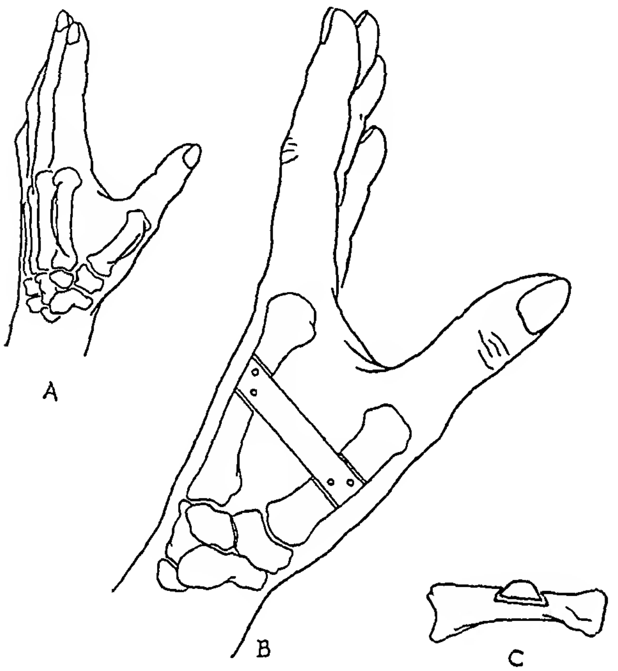

FIG 1

Details of operation, showing the curved incisions (A) the graft in position with drill-holes ready for sutures (B) and the cross-section of graft and undercut edges of the bed (C)

The graft is passed across the interspace and, with the thumb in full abduction and rotation, the lines of bone resection are marked on the metacarpals, with particular attention to obtaining maximal rotation of the first Saw cuts are then made so that the edges of each bed are slightly undercut (Fig 1C), steps about half the diameter of each bone are removed It is important to ensure that the beds for the graft are in the same plane when the thumb is in full opposition

The graft is then driven in from one end, because of the shape of its cross-section it is held snugly in the slots and rotation is controlled at once Two drill-holes are made through the graft and metacarpal at each end and chromic catgut sutures are inserted to maintain full abduction (Fig 1B) The ends of the graft are trimmed to leave no rough surfaces When subluxation of the trapezio-metacarpal joint is present, as may occur in young patients after poliomyelitis, the joint may be excised

Closure is effected by skin sutures only, and a plaster-of-Paris cast is applied Three weeks later the stitches are removed and a closely fitting plaster is applied for a further period of ten weeks, making three months in all

DISCUSSION OF RESULTS

The operation has been performed in sixteen cases In five the result was an unqualified success (Figs 2 and 3), in a further nine, despite some imperfections, the function of the hand was considerably improved The other two cases were failures

Causes of failure and poor results—These were 1) failure of fusion, 2) sepsis, 3) failure to achieve full opposition, 4) combined paralysis of the first dorsal interosseous and lumbrical muscles, and 5) " pollex valgus "

A B C

FIG 2

Case M96 Note the good abduction and rotation of the thumb and the normal opposition of the terminal phalanges

A B C

FIG 3

Case G34 Showing a good result despite partial sequestration of the graft

A B C

FIG 4

Case M184 opposition Pseudarthrosis at the second metacarpal end of the graft, but a useful range of active Note the secondary rotation arthrodesis of the metacarpo-phalangeal joint of the thumb

A B C

FIG 5

Case S104 To show the acquired deformity of "pollex valgus" following an opponens bone graft (A) the incomplete rotation of the first metacarpal (A) and the degree of passive correction allowed (B) In the relaxed position (A) the tendon of extensor longus pollicis is displaced to the ulnar side like the tendon of extensor longus hallucis in hallux valgus

1) *Failure of fusion*—Five grafts failed to fuse at one or other end but never at both In two of these cases absorption of the graft allowed the adduction deformity to recur and there was evidence to suggest that inadequate fixation after operation was the cause Where there was failure of fusion to the second metacarpal the disability was surprisingly slight, by using the long extensor and flexor tendons of the thumb alternately, the patient gained a range of movement through an arc the centre of which was the pseudarthrosis (Fig 4) Foerster had a similar experience and regarded pseudarthrosis at one end as a positive advantage

2) *Sepsis*—Sepsis occurred in three cases where the skin incision overlaid the graft, but with curved incisions this complication has not been seen In one case a sequestrum consisting of most of the graft was removed, but in spite of this a firm bony strut was formed (Fig 3C)

3) *Failure to achieve full opposition*—In five cases, although the thumb became fixed in full palmar abduction, rotation of the first metacarpal into full opposition was not maintained,

FIG 6

Case G41 In addition to the thenar paralysis there was complete intrinsic paralysis of the index finger arthrodesis of the proximal interphalangeal joint has been performed

FIG 7

Case R63 Another case showing incomplete rotation of the first metacarpal and "pollex valgus"

thus the pad of the thumb met the *side* of the distal phalanx of the index and gave a weak grip In one case arthrodesis of the metacarpo-phalangeal joint of the thumb in slight flexion and correct rotation was subsequently performed (Fig 4C) In another case a fracture of the first metacarpal occurred at the site of inlay during operation, and the opportunity to perform a rotation osteotomy was accepted with success

4) *Combined paralysis of the first dorsal interosseous and lumbrical muscles*—With a thenar paralysis, although the thumb lies in the plane of the palm, there is a strong grip between the pad of the thumb and the side of the second metacarpo-phalangeal joint In such a case, if the thumb is maintained in full abduction without full rotation the grip is transferred distally so that the side of the thumb and the side of the distal phalanx of the index meet Usually this is not a great disability, but if the first dorsal interosseous and lumbrical are

TABLE I—Inter-metacarpal Bone Graft [illegible] Paralysis

Case No	Nerve lesion	Associated deformities	Time after injury (months)	Donor site of graft	Duration of immobilsation (months)	Further operations	Duration of observation (years)	Result
A51	Brachial plexus, traction lesion	None	33	Ulna	5	None	3	Fair Incomplete rotation
B85	Median and ulnar, gun-shot wound	None	30	Tibia	3	None	4	Fair Absorption of graft, poor abduction
B66	Median, gun-shot wound	Multiple scars in vicinity of first cleft	29	Tibia	4	None	5	Fair Incomplete rotation
C127	Median and ulnar, gun-shot wound	No passive opposition Preliminary stripping of first metacarpal	16	Tibia	1½	None	4	Poor Absorption of graft, adduction recurred
G41	Median and ulnar, gun-shot wound	None	20	Rib	3	Arthrodesis of proximal interphalangeal joint of index	4	Good
G34	Median and ulnar, gun-shot wound	None	46	Ulna	4	Sequestrectomy	3	Good
M96	Median and ulnar, gun-shot wound	None	8	Tibia	3	None	5	Good
M84	Median and ulnar, laceration	None	26	Ulna	4	Rotation arthrodesis of metacarpo phalangeal joint of thumb	3	Good Pseudarthrosis at second metacarpal
M61	Brachial plexus, traction lesion	None	52	Ulna	5	None	3	Good
N41	Median and ulnar, gun-shot wound	None	15	Ulna	4	None	3	Good Pseudarthrosis at second metacarpal
R63	Median, gun-shot wound	None	7	Tibia	6	None	4	Fair Incomplete rotation, pollex valgus
R26	Median and ulnar gun-shot wound	No passive opposition Preliminary stripping of first metacarpal	36	Tibia	5	Sequestrectomy	5	Fair Pseudarthrosis at first metacarpal
S104	Brachial plexus gun shot wound	None	36	Ulna	4	None	3	Fair Incomplete rotation pollex valgus
W101	Median and ulnar gun shot wound	Marked contracture of skin in first cleft	22	Ulna	5	Plastic turntable flap at time of operation	4	Good
[illegible]	Brachial plexus [illegible] lesion	None	54	Ulna	3	None	3	Fair Incomplete rotation

paralysed the grip is weakened considerably since radial stabilisation of the index finger is impossible Furthermore, if full abduction and opposition are achieved by means of a bone graft and there is simultaneous paralysis of the first dorsal interosseous and lumbrical muscles, the tip of the index may fail to reach the pad of the thumb, because the long flexors, acting alone, cause the finger to fold up This disability was overcome in one case by performing arthrodesis of the proximal interphalangeal joint of the index in about 35 degrees of flexion (Fig 6)

5) "*Pollex valgus*"—This acquired deformity has been seen twice (Fig 5) It may have been due to paralysis of abductor pollicis brevis, on the other hand both these cases showed incomplete rotation of the first metacarpal (Fig 7) with ulnar displacement of the tendon of extensor pollicis longus, and it seems more probable that this is the important etiological factor The disability from such a deformity is more apparent than real because the abducted position of the first metacarpal permits a useful grasp even though opposition is defective

SUMMARY AND CONCLUSIONS

1 Sixteen cases of thenar paralysis are reviewed in which a bone graft was inserted between the first and second metacarpals to maintain fixed abduction and opposition of the thumb

2 The technique of the operation is described and the causes of failure are discussed

3 The operation is intended for those cases in which tendon transplantation to restore active opposition of the thumb is unsuitable Rotation of the first metacarpal into full opposition is the most important feature of the operation

I am most grateful to Mr H J Seddon for his helpful criticism to the staff of the Photographic Department of the Institute for the clinical photographs and to Miss Diana Stanley for the drawings

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THE RESULTS OF TREATMENT IN KIENBOCK'S DISEASE

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Kienbock's disease is not common but it occurs sufficiently often to be of orthopaedic importance The treatment and the prognosis are particularly important because most o the cases occur in heavy workers For this reason it is of interest to review the results o treatment in a series of patients from an industrial area

The condition was recognised by various observers before 1910, but it was Kienbock who first made a thorough study of the subject and tried to correlate the radiographic finding with the various clinical phases He held that the condition was a malacia of the lunate bone from interference with the blood supply through the ligaments This he attributed to injury which could be caused by a momentary subluxation of the bone ("jump subluxation") Such fractures as might occur he regarded as secondary

Persson (1945) agreed with the view originally advanced by Hultén (1928) that an important etiological factor is relative shortening of the lower end of the ulna with increased prominence of the articular surface of the radius, so that the lunate bone is exposed to greater stress in compression injuries of the wrist This anatomical state, which Persson termed the "minus variation," was found in 8 per cent of the general population, but in as many as ten of his nineteen cases of Kienbock's disease This variation was present in a much smaller proportion of our cases Persson advocated lengthening the ulna and reported good results He believed that the operation relieved mechanical stress and so enabled the lunate bone to regenerate

The condition has also been considered due to primary fractures, aseptic emboli and osteitis, but is now generally ascribed to avascular necrosis from traumatic interference with the blood supply

TABLE I

Cases according to Age Groups

Age in years	Cases	No operation	Operation
10 – 19	5	3	2
20 – 29	14	3	11
30 – 39	13	11	2
40 – 49	9	8	1
50 and over	2	2	0
Total	43	27 (63%)	16 (37%)

For the purpose of this paper a review has been made of the patients with Kienbock's disease under my care in the past ten years In all there were forty-six three, treated conservatively, could not be traced, forty-two were seen and examined, the remaining patient failed to attend but the result was assessed from hospital records Of the forty-three traced patients forty were male and three female, thirty-eight were heavy workers, includin twenty-five coal-face workers, and five were light workers, including one housewife Th right wrist was affected in twenty-four cases and the left wrist in nineteen Twenty seve patients were treated conservatively Of these, twenty-two were treated by immobilisation f an average period of three to four months, two were treated by rest and physiotherapy, an three had no specific treatment except a period of rest from work Sixteen patients wer treated by excision of the lunate bone, six as a primary measure and ten after a period o

conservative treatment had failed to give relief One patient was treated by arthrodesis of the wrist after an unsatisfactory result from excision

Operation—The usual posterior approach was used, with a longitudinal incision, division of the sheath of extensor digitorum communis, and displacement of the tendons Care was taken to make the excision complete, with the least possible injury to the other carpal bones This was facilitated by continuous traction on the hand by an assistant No post-operative immobilisation was used, movements of the fingers being encouraged from the beginning and wrist movements after a few days

Results were classified as *excellent*, no complaints and capable of full work without difficulty, *good*, capable of full work without loss of time, but symptoms after very heavy use, *fair*, improvement in symptoms but unable to resume heavy work, *poor*, no improvement, with persistent weakness and pain in the wrist

It was found that the quality of the functional result was not always directly proportional to the final range of movement Freedom from pain on movement, especially forced movement, and strength of grip were more important criteria of a good functional result There was usually some weakness of grip, but in cases described as excellent this was slight

Table II shows that of the patients who were traced 63 per cent returned to full work after conservative treatment In this group the three patients receiving no specific treatment had good or excellent results Of the two treated by physiotherapy alone, one had a good and the other a fair result

TABLE II

ANALYSIS OF RESULTS OF CONSERVATIVE TREATMENT

Age in years	Excellent	Good	Fair	Poor	Total
10 – 19	0	3	0	0	3
20 – 29	1	0	1	1	3
30 – 39	5	2	3	1	11
40 – 49	3	3	2	0	8
50 and over	0	0	1	1	2
Total	9 (33%)	8 (30%)	7 (26%)	3 (11%)	27

TABLE III

ANALYSIS OF RESULTS OF EXCISION

Years after operation	Excellent	Good	Fair	Poor	Total
4 – 6	3	1	2	1	7
2 – 4	1	2	0	0	3
1 – 2	2	0	2	0	4
0 – 1	1	1	0	0	2
Total	7 (44%)	4 (25%)	4 (25%)	1 (6%)	16

Table III shows that 69 per cent of patients returned to full work after excision of the lunate bone One patient with a poor result was treated subsequently by arthrodesis of the wrist over two years ago, this gave considerable improvement, but he has not resumed his full pre-accident work as a steel worker The result in the patient assessed from hospital notes is recorded as "fair" in the top line

In attempting to compare the results of excision with those of conservative treatment it is difficult to select comparable groups because of the uncertain duration of the pathological process in a high percentage of cases, for instance those with obviously long-standing radiographic changes but with only a recent history of injury Since excision of the l . .

was not advised in elderly patients, or in the presence of gross arthritic changes, the choice of operation was virtually limited to patients under forty years of age It was thought that the group of patients under the age of forty years who were treated conservatively was on the whole comparable with the group in which excision was undertaken Reference to Table II shows that the results of conservative treatment in this age group differs little *from the results in the whole series, 65 per cent returning to full work*

DISCUSSION

This series of cases was drawn mostly from a mining community The prognosis appears on the whole better than is usually supposed, because a fairly high proportion of patients returned to heavy work after either conservative or operative treatment In fairly comparable groups the results of treatment whether by conservative measures or by removal of the lunate bone were not strikingly different

In most patients treated conservatively with success the period of fixation was not long and only two patients required more than three months Often the length of the history or the radiographic appearances showed that the condition had been latent for a long time and had been revealed only by a recent injury causing definite symptoms In such cases a period of rest has been sufficient to restore quiescence and satisfactory function and to allow return to heavy work for a number of years This seems to indicate a period of immobilisation for all patients, unless there are special reasons for primary excision of the lunate bone

Arthrodesis of the wrist is valuable as a last resort, when there is persistent pain with gross osteoarthritis of the carpal joints It does not, however, restore efficiency for many of the heavier types of work

Has excision of the lunate bone a place in treatment? In those cases treated successfully by removal of the lunate bone, a striking result was the frequency of relief from aching pain The strength of grip, although usually diminished just after the operation, gradually returned, though in some cases only after many months None of the cases regarded as satisfactory has deteriorated In my opinion removal of the lunate bone is justified in the few cases where there is no gross osteoarthritis, and where aching pain persists after efficient immobilisation for three or four months

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A CASE OF RUPTURE OF FLEXOR TENDONS SECONDARY TO KIENBOCK'S DISEASE

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Pathological rupture of the flexor tendons at the wrist is uncommon Colles fractures probably account for most cases, displaced fragments may cause attrition, or secondary arthritis may lead to degenerative changes in the related tendons and tendon sheaths McMaster 1932) The case reported here of an unusual cause of rupture may be of some interest

Case history—F R, aged fifty years, a motor driver, attended the Hand Clinic at the Royal National Orthopaedic Hospital complaining of aching pain in front of the left wrist of nine years' duration In the first place the hand and fingers became swollen for one day

Fig 1

Pre operative photograph showing limitation of active flexion of the thumb and index finger

Fig 2

To show the improvement in active flexion of the thumb and index finger six months after operation

and he stayed away from work for two days, there was no history of injury Four months before reporting he found that he was unable to flex the distal joint of the index finger This loss of power happened for no apparent reason and without pain Three months later, though he was not using his hand, it suddenly became cramped and assumed the obstetric position There was severe pain, and when this and the cramp subsided he was unable to flex the interphalangeal joint of the thumb

When he was examined one month later, a soft tissue swelling was visible in front of the wrist, and proximal to this, some hollowing of the radial half of the anterior surface of the forearm He could not flex the distal joint of the thumb or of the index finger (Fig 1) Dorsiflexion and radial abduction of the wrist joint were limited by approximately one-third There was no loss of sensation in the hand and no wasting of the thenar muscles

Radiographs of the wrist revealed longstanding Kienbock's disease of the semilunar bone which was dense and much compressed In the lateral view several loose fragments could be seen in front of the proximal row of the carpus (Fig 3)

Treatment—The flexor tendons were exposed at the wrist and the transverse carpal ligament was divided The median nerve was normal The tendons of flexor pollicis longus and flexor

FIG 3
Radiographs of the wrist showing the dense fragmented semilunar bone

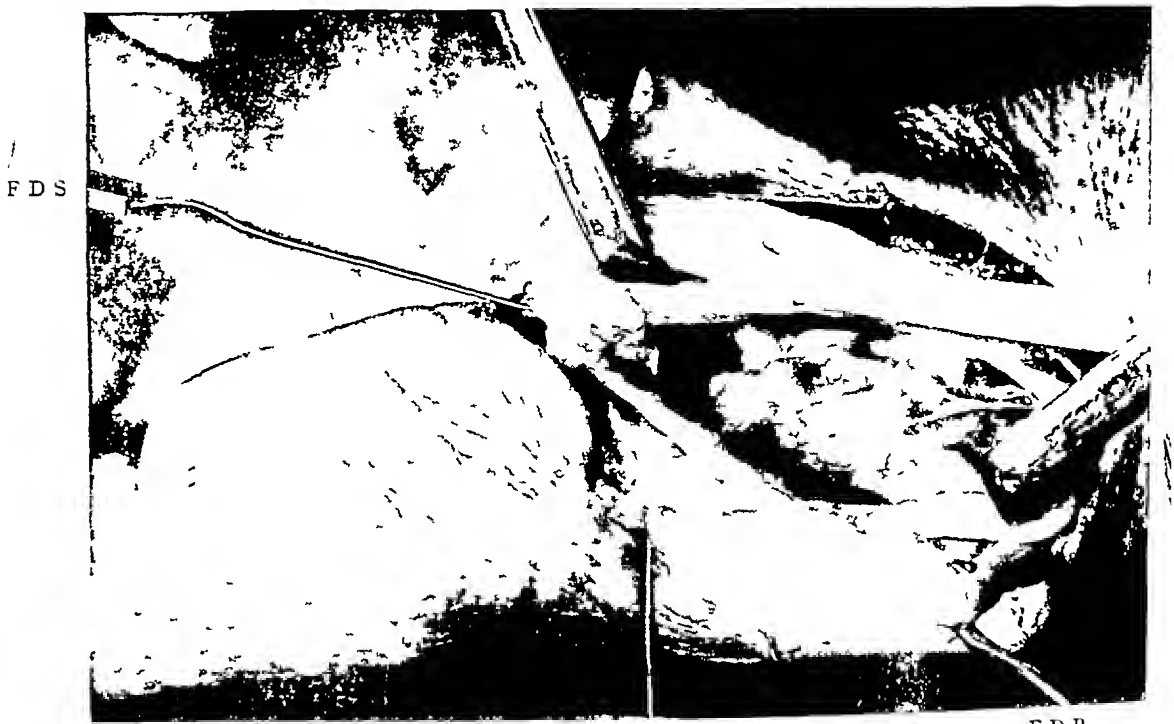

FIG 4 Showing ruptured and frayed tendons F D P—flexor profundus to the index finger in continuity with its empty tendon sheath F P L—flexor pollicis longus similarly affected F D S—flexor sublimis to the index finger severely frayed The aperture in the capsule can be seen in the angle between flexor profundus and flexor sublimis

FIG 5
The fragments of semilunar bone

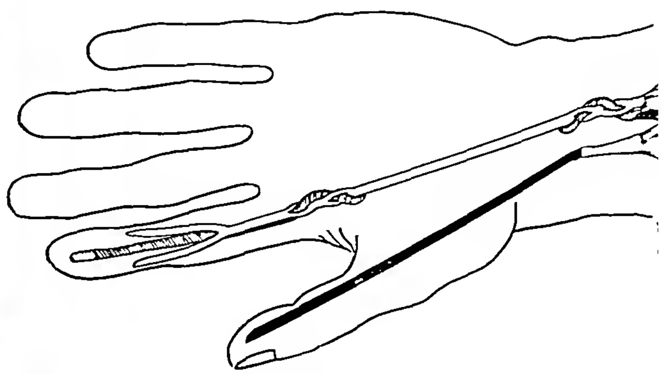

FIG 6
The plan of the tendon repair

profundus to the index finger were found to be completely divided and separated by a gap of two and a half inches, across which ran the empty tendon sheaths (Fig 4) The ends of each tendon had rounded off smoothly and there was no fraying The adjacent tendons of flexor sublimis to the index and of flexor profundus to the middle finger were, however, grossly frayed like ropes worn half through On exposure of the anterior capsule of the wrist an aperture was found leading to the affected semilunar, with flexion of the joint three small loose bodies were extruded (Fig 5) The semilunar was excised, a dorsal incision being required for one mobile fragment

Repair of the tendons was then effected (Fig 6) The distal part of the tendon of flexor pollicis longus was resected A long free graft from the extensor tendon of the third toe was then sutured in position by the Bunnell technique The graft lay between the proximal end of the ruptured tendon and the insertion of flexor pollicis longus into the distal phalanx Both proximal and distal ends of the profundus tendon to the index finger were sutured to the corresponding sublimis tendon with the finger in flexion A plaster cast was applied with the thumb, index finger and wrist flexed and was retained for four weeks

The post-operative recovery was uneventful Six months after operation there were 10 degrees of active flexion of the distal joint of the index finger and the finger was no longer hyperextended when at rest Active flexion of the interphalangeal joint of the thumb was strong through 15 degrees (Fig 2) The patient found little disability in either digit and the wrist was painless

Comment—The damaged flexor tendons are anatomically those most closely related to the semilunar It is surmised that during flexion and extension of the wrist these tendons were pulled taut across the displaced fragments No similar case has been discovered in an extensive search of the literature

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INTER-CARPAL DISLOCATIONS AND FRACTURE-DISLOCATIONS

A Review of Fifty-nine Cases

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Most of the patients in this series were treated at some stage in Royal Air Force Hospitals during the recent war About a quarter of the total were seen or treated personally, the remainder being assessed by examination of their case-records and radiographs Probably all except one of these patients sustained their injuries as a result of forcible dorsiflexion of the wrist joint, but the exact mechanism of injury could seldom be determined It should be emphasized that almost all the results are early, a late follow-up of the Service cases has not been possible The results have been assessed for convenience as "good"—a painless wrist with an adequate range of movement, "fair"—slight pain and stiffness insufficient to interfere with most normal activities, and "poor"—a painful, weak or very stiff wrist

It will be seen that although anterior dislocations of the lunate bone are generally considered to be the most common type of inter-carpal dislocation, trans-scapho-perilunar dislocations outnumber them in this series by almost two to one It is possible, however, that dislocations of the lunate were more often treated in general surgical units and not referred to orthopaedic departments Otherwise the series probably gives a reasonably accurate indication of the relative incidence of the various injuries

FIG 1

The radiographs of a case of trans-scapho-perilunar fracture-dislocation Satisfactory reduction was obtained and four months later the scaphoid was uniting

TRANS-SCAPHO-PERILUNAR FRACTURE-DISLOCATION—TWENTY-SEVEN CASES

This injury is not a common one and the radiographs may be misinterpreted (Fig 1), thus nine cases had been labelled "dislocated lunate," "fractured scaphoid" or "congenital abnormality of the carpus"

Clinical features—Before it is obscured by marked swelling, backward displacement with increased antero-posterior thickness about the mid-carpal level is apparent, and the proximal margin of the capitate may be palpable on the dorsum Radial deviation of the hand is usually present together with painful restriction of wrist and finger movements

Associated injuries—The ligamentous injury is inevitably severe and chip fractures, damage to articular surfaces and fractures of the styloid processes are common Thus one or both styloid processes were fractured in ten of the cases, the capitate twice, and the triquetrum, pisiform and fourth metacarpal in single instances

Complications—Avascular necrosis of the proximal scaphoid fragment occurred in thirteen or approximately half the cases Transient median nerve paralysis was noted only twice

Treatment—"Early" cases seen within fourteen days of injury could usually be reduced by closed manipulation, with steady manual traction, the wrist was gradually brought into flexion and slight ulnar deviation and a forearm plaster including the proximal joint of the thumb was applied Twenty patients were seen early, closed reduction was obtained in all, although in three a slight rotational subluxation or lack of complete apposition between the scaphoid fragments persisted Two cases were successfully reduced eleven and twelve days after injury It is sometimes advised that the wrist be immobilised in the neutral position after the first week, but in two cases dorsal subluxation tended to recur, and it would seem wise to maintain palmar flexion for three weeks after reduction

Treatment of the "late" case—Closed reduction failed in two "late" cases seen three weeks after injury, and attempts at closed reduction after this period may cause more damage to the wrist than careful open reduction Open reduction was performed in two cases, four and six weeks after injury When more than six weeks had elapsed without reduction, and the wrist remained painful after a fair trial, arthrodesis of the wrist joint was advised

Treatment of avascular necrosis—Three different lines of treatment were adopted when the diagnosis of avascularity of the proximal scaphoid fragment was made bone grafting, three cases, excision of the avascular fragment, four, and continued immobilisation, five When excision was carried out, the operation was performed as soon as the diagnosis was made, normally six or eight weeks after injury, and immobilisation was continued for a further two or three weeks It is to be noted, however, that early excision of a large scaphoid fragment in the presence of a lax ulnar collateral ligament jeopardises the stability of the wrist In this small series the results of excision and of continued immobilisation were approximately equal, grafting was disappointing

Results—(i) *Closed reduction and immobilisation only*—Eleven cases The average period of immobilisation was almost five and a half months Sound bony union of the scaphoid occurred in four cases, all with a good result, in one of these avascularity of the proximal fragment had been noted In five cases it was thought probable that bony union had occurred, despite an avascular fragment in one case, one result was good, one fair, and three were not recorded In two cases with avascular necrosis non-union was accepted after five and seven months of immobilisation, the functional result, however, was good in one patient who returned to duty as a pilot and fair in the other

(ii) *Closed reduction followed by excision of an avascular scaphoid fragment*—Four cases One was a failure and the wrist was arthrodesed nine months later, another had a fair result in spite of radial deviation of the hand, in the remaining two the results were good

(iii) *Closed reduction followed by scaphoid grafting or simple drilling*—Five cases Four patients had a cortical peg graft inserted into the scaphoid by the "closed" or "blind" method, two already had an avascular proximal fragment, and one grafted four weeks after injury later showed radiographic evidence of avascularity In one the scaphoid failed to unite and the result was poor In the other three, union was obtained, the functional result remained poor in two but promised well at six months in the third In one patient simple drilling of the scaphoid was performed eleven weeks after injury, union was not sound five months after operation

(iv) *Open reduction*—Two cases This was performed twice, four and six weeks after injury In the first case, despite an avascular fragment, the scaphoid united after seven months immobilisation The patient was last seen only two weeks later but was then moving his wrist well In the second case the proximal part of the scaphoid was removed at the time of operation because it was thought certain that its blood supply had been impaired, the functional result was good

(v) *Late unreduced cases*—Five cases These were seen at periods from three weeks to seven months after injury Three had successful arthrodesis of the wrist and another was thought likely to require arthrodesis The fifth had a weak and stiff but painless wrist nine months after injury, with some crepitus in the sheaths of the flexor tendons to the fingers

DISLOCATION OF LUNATE—FOURTEEN CASES

All cases showed anterior displacement (Fig 2) In two instances the original radiographs had been reported as normal, thus accounting for some delay in treatment

Clinical features—Wrist movements were limited and the fingers were held in semiflexion tingling, numbness or pain in the median nerve distribution were common The displaced lunate was sometimes felt as a prominence on the anterior aspect of the wrist, with a corresponding depression on the dorsal aspect

Associated injuries—The lunate bone itself, the triquetrum and the capitate were each fractured in single instances

Complications—A transient median palsy was recorded in four cases and in one patient persisted for more than three months Vascular changes in the bone were notable for their absence Only one lunate showed increased relative density but with no evidence of collapse or necrosis, after three previous attempts at reduction the dislocation had been reduced by skeletal traction seventeen days after injury, by which time skin ulceration had developed in front of the wrist The radiographic appearances in this case did not resemble Kienbock's disease MacAusland (1944) found no record of Kienbock's disease after dislocation of the lunate, even with open reduction It seems unlikely therefore that this "disease" can result from a single injury of the type that causes dislocation of the lunate, in which some blood supply to the bone is usually preserved through the intact palmar radio-carpal ligament

Fig 2
Typical radiographs of anterior dislocation of the lunate

Treatment—In cases seen within ten days of injury, reduction by traction and direct digital pressure on the displaced lunate was usually accomplished quite easily The wrist was immobilised in palmar flexion for about a week and in the neutral position for a further two weeks

Of nine "early" dislocations eight were reduced in this way, one, though seen within two days, required the use of a distraction frame with Kirschner wires through the olecranon and the necks of the metacarpals

Five patients were seen "late" with unreduced dislocations at intervals varying from two weeks to three months after injury One was reduced on a distraction frame at seventeen days, and the remaining four had the lunate excised by the anterior approach Operative reduction was not attempted in any case

Results—Of the ten patients whose dislocations were reduced, six had a good result, one patient with almost full movement still complained of pain six months after injury and was therefore classified as fair, in two the injury was too recent for assessment but progress was satisfactory

The patient whose dislocation was reduced by skeletal traction seventeen days after injury had a poor result. After eighteen months he had rather a stiff wrist with discomfort in cold weather and there was still some radiographic evidence of bone atrophy.

The results in the four cases of excision were satisfactory, all the patients having a good grip, a painless wrist and adequate movement, except for some limitation of palmar flexion.

FORWARD DISLOCATION OF LUNATE AND HALF OF SCAPHOID—SIX CASES

Certainly in its clinical features, and probably in the mechanism of its production, this injury is similar to simple anterior dislocation of the lunate. In five cases the proximal fragment of the scaphoid dislocated forwards with the lunate as usual, but the *distal* fragment was displaced with the lunate in one case.

Associated injuries—The triquetrum was fractured twice and both styloid processes once. One fracture-dislocation was compound.

Complications—A transient median palsy occurred four times and avascular necrosis of the proximal scaphoid fragment was observed in three cases.

Treatment—Reduction was usually obtained by the same type of manipulation as for simple dislocation of the lunate, but it was more difficult and failed in two cases, one seen within a few hours of injury and the other after ten days. After reduction the wrist was immobilised in forty degrees of palmar flexion for three weeks, the plaster including the proximal joint of the thumb. Thereafter the wrist was maintained in the neutral or slightly dorsiflexed position, as a rule until the scaphoid was united.

In both cases where closed reduction failed the displaced lunate and scaphoid fragment were excised. In two others the scaphoid fragment, although reduced, was excised on account of avascularity.

Results—Two patients treated conservatively throughout obtained reasonably good results: in one, bony union of the scaphoid was secured after six months in spite of avascularity of the proximal fragment, but in the other union remained doubtful after four months. Of the two cases treated by excision of the avascular proximal scaphoid fragment, the result was fair in one but not recorded in the other. Excision of the unreduced lunate and portion of scaphoid gave one good and one fair result.

PERILUNAR DISLOCATION OF THE CARPUS—THREE CASES

In this injury the scaphoid remains intact and undergoes rotational subluxation as the carpal bones are displaced backwards on the lunate, thus the tubercle of the scaphoid comes to point into the palm and the proximal pole faces backwards. The treatment is the same as for the similar trans-scaphoid dislocation, except that the wrist need be immobilised for only three or four weeks.

Two early cases were reduced by manipulation, one with a good result, the other not yet assessed. The third patient was first seen three months after injury with the dislocation unreduced; despite antero-posterior broadening of the wrist and gross limitation of wrist movement, the grip was good and there was little pain in the wrist. One patient had a transient median palsy, but no vascular complications were seen.

SUBLUXATION, RECURRENT SUBLUXATION, AND DISLOCATION OF THE SCAPHOID—FIVE CASES

Subluxation of the scaphoid—one case. In this condition the scaphoid undergoes a rotational subluxation with dorsal displacement of the proximal pole. In one patient who was seen early the antero-posterior radiograph showed a gap between the scaphoid and lunate bones (Fig. 3A). The injury, however, was complicated by fractures of the radial styloid and triquetrum and by a previous atrophic arthritis of the wrist. The displacement was reduced with the wrist in dorsiflexion and radial deviation; this position was maintained for six weeks and the reduction remained stable (Fig. 3B).

Recurrent subluxation of the scaphoid—three cases Three patients had sustained their injuries from three months to two years before examination and the subluxation had become recurrent They complained of a click, usually painful, when the wrist was flexed in the palmar direction There was also some impairment of wrist movement and of grip Th subluxation could be confirmed from the radiographs The characteristic click on flexion of the wrist may be due to the radial extensor tendons slipping over the projecting proximal pole of the scaphoid, but more probably to the scaphoid slipping over the posterior margin of the radius It can be eliminated by pressure over the postero-lateral aspect of the wrist

When subluxation is recurrent and the symptoms warrant operative treatment, it probably best to make the reduction secure by arthrodesis of the scaphoid to the lunate bo In one case so treated the interosseous scapho-lunate ligament was absent and the dorsal radio-carpal ligament was very much attenuated After removal of the adjacent articular cartilage, small bone chips from the lower end of the radius were packed between the two bones and the wrist was immobilised in plaster for four and a half months Although sound fusion was doubtful, the patient had a useful range of wrist movement, a fairly powerful grip and no symptoms seven months after operation In another patient with recurrent subluxation the scaphoid was excised, the result was not satisfactory The third patient simply had manipulation of the wrist followed by active exercises, as his symptoms were relieved at the time this simple treatment may be worth a trial before scapho-lunate arthrodesis is considered

FIG 3A
Subluxation of the scaphoid in an arthritic wrist, the radial styloid and triquetrum were fractured

FIG 3B
The same case after reduction, which remained stable

Dislocation of the scaphoid—one case This injury was sustained in a fall off a motor-cycl The wrist was locked in ulnar deviation (Fig 4) and a tender prominence was palpable ne the tip of the radial styloid process The radiographs showed the proximal pole of th scaphoid lying on the postero-lateral aspect of the radial styloid and the tuberosity tilt anteriorly, the capitate had slipped proximally towards the scaphoid space (Fig 5)

Manipulative reduction was not difficult, traction being used on the hand and dir pressure on the displaced scaphoid The wrist was immobilised in dorsiflexion and abducti for five weeks Three months after injury, wrist movements were approximately th quarters of normal, the patient had a powerful grip without pain, and there was radiographic evidence of impairment of the blood supply to the scaphoid

OTHER CARPAL DISLOCATIONS

Anterior dislocation of the trapezium—one case This was a compound injury caused a metal box falling on the hand The trapezium was dislocated forwards on the scaph

FIG 4

A case of dislocation of the scaphoid showing ulnar deviation of the hand

FIG 5

Radiographs showing dislocation of the scaphoid The proximal pole is lying on the postero-lateral aspect of the radial styloid and the tuberosity is tilted anteriorly

carrying the first metacarpal with it, the base of the second metacarpal was fractured Reduction was not obtained at the time of wound excision and the dislocation was accepted plaster fixation being discarded after eighteen days Ten weeks after injury, the patient had full wrist and finger movement and a fairly powerful grip Apart from some loss of dexterity and slight pain when grasping with the thumb and index finger, the function of the hand was normal

Posterior dislocation of trapezoid—one case This patient was first seen two months after injury The deformity was obvious, wrist movement was limited and painful when forced Radiographs showed the trapezoid displaced backwards together with the second metacarpal No special treatment was undertaken and the patient was invalided from the Service six months later

FIG 6
Anterior dislocation of lunate and perilunar dislocation of carpus with fracture of the tip of the radial styloid

Anterior dislocation of lunate and perilunar trans-styloid fracture-dislocation—one case The patient, a man aged fifty-six years, sustained this injury when his sleeve wa caught in moving machinery Radial displacement could be seen and the finger and wri movements were markedly restricted Radiographs showed an anterior dislocation of th lunate, a postero-lateral shift of the other carpal bones and a fracture of the radial styloi process (Fig 6) The displacement was reduced and the wrist immobilised in palmar flexio and ulnar deviation After ten days the degree of palmar flexion was reduced and th plaster was discarded after a further four weeks The patient returned to his work a brass-finisher three and a half months after injury The radiograph now shows the comm tendency for a lunate bone which has been dislocated to tilt backwards A year afte injury the patient is working and has only slight discomfort, movements are almost full

Dislocation of capitate and trapezoid—one case This patient, aged seventy-one year was knocked down by an omnibus A wound extended along the distal crease of the wr and round the ulnar side to the dorsum The radiograph showed postero-medial dislocati of the capitate together with the third and fourth metacarpals, and posterior dislocation the trapezoid carrying the second metacarpal (Fig 7) In addition, a triangular fragment bone had been separated from the posterior margin of the base of the third metacarpal

At operation the medial articular surface of the capitate was readily visible on t dorsum of the hand The skin on the ulnar side of the hand could not be closed complete but elsewhere it was sutured after reduction of the dislocation Plaster was applied w

the wrist joint in palmar flexion and the unsutured area was covered by a split-skin graft twelve days later The wounds healed cleanly and immobilisation was discontinued after a total of ten weeks Six months after the injury the patient had no pain, a powerful grip and approximately one-third of the normal wrist movement

SUMMARY AND CONCLUSIONS

1 Fifty-nine patients with various inter-carpal dislocations have been reviewed

2 In this series trans-scapho-perilunar fracture-dislocation was the commonest injury Early cases can be reduced by closed manipulation but in late cases operative reduction is usually advisable When the injury is more than three months old, arthrodesis of the wrist joint is indicated

FIG 7

Dislocation of capitate with the third and fourth metacarpals and of the trapezoid with the second metacarpal

3 When trans-scapho-perilunar fracture-dislocation was complicated by avascular necrosis of the proximal scaphoid fragment, the results in a small series treated by early excision were approximately equal to those treated by continued immobilisation The results of grafting the scaphoid were poor

4 Dislocations of the lunate seen within ten days of injury could usually be reduced with good results, no such case developed Kienbock's disease within the period of review In late cases excision gave satisfactory results

5 Forward dislocation of the lunate with half the scaphoid gave good results when manual reduction succeeded, but the results of excision of fragments were less satisfactory

6 There was one case of forward dislocation of the lunate together with the *distal* half of the scaphoid

7 Subluxation of the scaphoid is disclosed in antero-posterior radiographs by a typical gap between it and the lunate bone The subluxation may become recurrent and present a characteristic syndrome

8 Other rare dislocations of the carpal bones are described

These patients have been treated under the supervision of Sir Reginald Watson-Jones Mr H Osmond-Clarke Mr I L Dick and Mr Alexander Miller and I wish to acknowledge my indebtedness to them

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A CASE OF RECURRENT SUBLUXATION OF THE CARPAL SCAPHOID

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While fractures of the carpal scaphoid are common, isolated dislocations and subluxation of this bone are rare The case of recurrent subluxation reported here seems to merit recording, particularly in view of the well-defined symptoms, signs and radiographic findings

A man aged thirty-one years attended the London Hospital in June 1948, complaining that three months earlier he had "sprained" his right wrist while playing Rugby football He was not sure of the exact nature of the injury and did not think much of it at the time Later he noticed that forced palmar-flexion of the right wrist joint caused pain over the radial half of the dorsum of the joint and, in particular, that during rapid dorsiflexion, as in the act of throwing a dart, the wrist would click and he would momentarily lose the power of grip

On examination the wrist showed no external abnormality and no loss of movement in any direction The grip was strong, but dorsiflexion movement caused an audible snap in the joint, after which the proximal pole of the scaphoid could be seen to be unusually prominent on the dorsum of the joint The snap was very much under voluntary control and could be produced or suppressed at will

The first radiographs showed no abnormality (Fig 1), but with the patient's co-operation it was possible to take films while the proximal pole of the scaphoid remained prominent on the dorsum (Fig 2) These radiographs showed that the scaphoid was in fact subluxated that the distal pole looked straight forward and the proximal pole straight backwards, the long axis of the bone was then at right angles to the long axis of the forearm This can be seen clearly in the lateral view, in the antero-posterior view the scaphoid has a distorted foreshortened appearance, with a space between it and the radial side of the semilunar bone

The patient had such perfect control over his disability that he was unwilling to have anything much done in the way of treatment, least of all any operative measure such as scapho-lunate arthrodesis, but he did agree to wear a moulded leather wrist-strap which was prescribed in the hope that if the subluxation were prevented for six to eight weeks the stretched capsule of the wrist joint might contract sufficiently to ensure stability After three months, however, he could still produce the subluxation at will and declined to put up with the inconvenience of the strap any longer

Comment—The picture of recurrent subluxation of the carpal scaphoid is a clear one An obscure injury to the wrist joint is followed by snapping of the joint during dorsiflexion with momentary loss of grip and the appearance of a dorsal prominence over the scaphoid Radiographs taken during displacement show the scaphoid lying in the antero-posterior direction with the proximal pole on the dorsum, and a gap between the scaphoid and semilunar

FIG 1

Antero posterior and lateral views of the wrist joint with the subluxation reduced showing normal radiographic appearances

FIG 2

Radiographs taken with the subluxation being maintained voluntarily In the antero posterior view note the wide gap between the scaphoid and the semilunar the scaphoid appears foreshortened and the distal pole overlies the head of the os magnum In the lateral view the axis of the scaphoid is seen to be antero posterior *Inset* Complete continuous line the scaphoid dotted line the semilunar interrupted line the os magnum posterior curved line the cuneiform

OSTEOARTHRITIS OF THE TRAPEZIO-METACARPAL JOINT

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The trapezio-metacarpal joint is the most important site for hypertrophic arthritis in the hand The condition has been studied in France by Charcot and by Leri (1926), Robert (1936), Forestier (1937) and Huc and Badie (1941) We recently continued this work from both the radiological and clinical view, especially with regard to early diagnosis

Anatomically, the trapezium is an intermediate bone placed in a particularly vulnerable position between the hammer of the first metacarpal and the anvil of the scaphoid The normal arrangement of the bones is well known, but in about one case out of fifty the distal margin of the trapezium shows a marked exaggeration of the normal concavity (Fig 3)

Physiologically, there are two main movements at the trapezio-metacarpal joint antero-posterior flexion which is visible but difficult to analyse in radiographs, and lateral

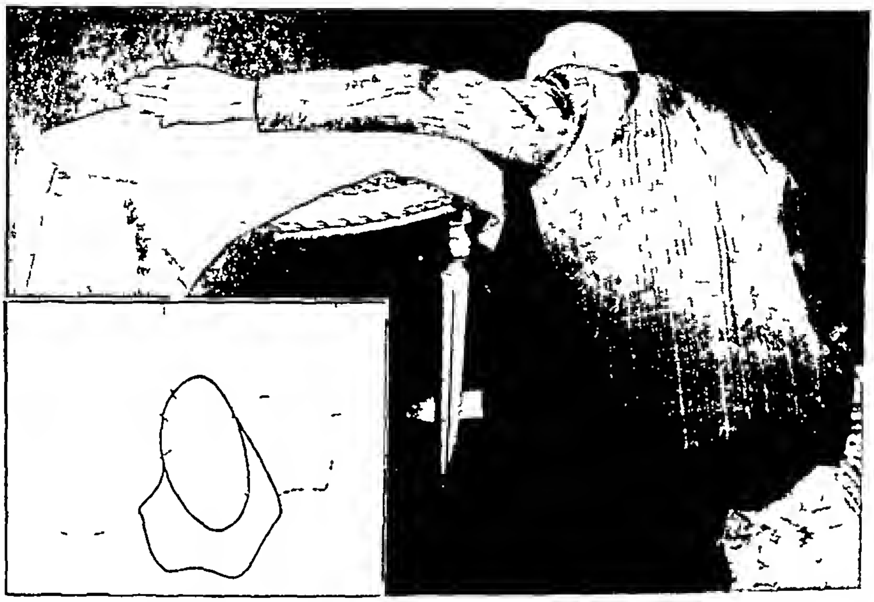

FIG 2
To show the superimposed rounded outline obtained with incorrect positioning

FIG 1
The radiographic position which ensures clear outlines of the trapezium the forearm and hand are fully pronated

movement permitting abduction and adduction which is easy to study from radiographs made in forced pronation These two movements are combined during opposition Let us consider the lateral movement During abduction the metacarpal fills exactly the transverse hollow of the trapezium (Fig 4), but in adduction it slides laterally tending to leave the medial part (Fig 5) The amount of sliding is usually very little, but in some cases the medial third of the hollow is uncovered In rare instances the metacarpal is subluxated even during abduction, and this permanent physiological subluxation is a cause of error to be avoided (Fig 6) The "step" sign of Forestier, *le signe de la marche d'escalier*, consists of deformity of the base of the thumb caused by this radial subluxation of the first metacarp

Radiologically, the diagnosis of trapezio-metacarpal arthritis was difficult and uncertai until Robert (1936) demonstrated the value of placing the hand in forced pronation Th standard dorso-palmar film is of no practical use at all, except in advanced cases when merely confirms the presence of a grave lesion of the joint We must draw attention possible errors in the interpretation of dorso-palmar views At the level of the trapezium

FIG. 3
Exaggeration of the normal concavity of the trapezium and prolongation of the medial and distal angle.

FIG. 4
In abduction of the thumb the base of the first metacarpal exactly fills the transverse hollow of the trapezium.

FIG. 5
In adduction of the thumb the base of the metacarpal glides laterally.

FIG. 6
Showing marked physiological subluxation of the metacarpal.

FIG. 7
Showing narrowing of the joint space sclerosis of subchondral bone and osteophyte formation.

FIG. 8
Osteophyte formation on the medial and distal angle of the trapezium and lateral subluxation of the metacarpal.

FIG. 9
To show osteophytes of unusual size at both the lateral and medial margins of the joint.

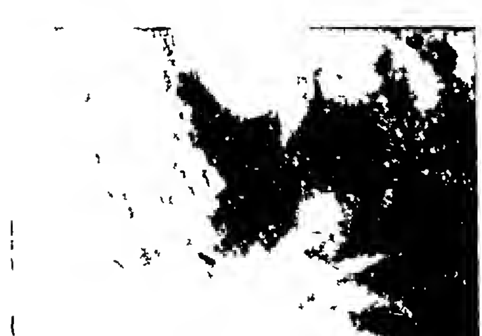

FIG. 10
La forme subluxante maxima: the base of the metacarpal is level with the trapezio-scaphoid joint.

oval image can often be seen with the long axis directed inwards and distally like the stone of a ring set obliquely (Fig 2) The image ends in a rounded outline over the proximal ends of the first and second metacarpals It is caused by the projection of the medial and distal part of the trapezium on to the rest of the bone If an abnormality of the trapezio-metacarpal joint is suspected, a radiograph should be taken in a position of forced pronation, together with a view in profile The position of the patient is important To have the whole trapezium and all its borders properly displayed, the patient should kneel beside the table with the head bent forwards, the arm horizontal and the shoulder level with the hand (Fig 1).

There are two groups of cases

1) **Early trapezio-metacarpal arthritis**—Very often symptoms first arise during manual work Radiographic changes in the joint may include *a*) Narrowing of joint space A reduction of 1 0 to 1 5 millimetres is common, but what is the margin of error? Stereoscopic examination always shows that the joint *space is better outlined and much wider than it* appears in routine radiographs *b*) Subchondral condensation of bone *c*) Lateral subluxation *d*) Osteophyte formation on the lateral borders of the metacarpal and trapezium Though this is given as an early sign by many writers, we have not been able to find it with any certainty in early cases *e*) Deformation of the medial and distal angle of the trapezium This is common and consists of an alteration in the distal curve of the trapezium beginning near the junction of the inner third and the outer two-thirds, prolongation of the distal and medial angle into the space between the proximal extremities of the first two metacarpals, and early osteophyte formation in the same region (Figs 7 and 8) We think that the medial part of the articular surface is the starting point of the arthritic process and that this corresponds to the area where pressure transmitted through the adducted thumb is most frequently and powerfully felt

FIG 11
A suitable appliance

2) **Gross trapezio-metacarpal arthritis**—The diagnosis can be made clinically and the radiographs show clear details of the lesion (Fig 9) In an extreme case dislocation can be so marked that the base of the metacarpal is opposite the trapezio-scaphoid joint This is the type with maximum subluxation, *la forme subluxante maxima* (Fig 10) The joint space is not visible, but screening during movement shows that it is partly preserved In all cases the greatest deformity and largest osteophytes are at the distal and medial angle of the trapezium This is a point of first importance

Treatment—At the least suspicion of trouble the patient should wear an apparatus to hold the trapezio-metacarpal joint at rest in abduction (Fig 11) We demonstrated a suitable appliance made of a very light plastic material (Paladon) at the International Scientific Conference held at Aix-les-Bains in June 1948

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EXCISION OF THE TRAPEZIUM FOR OSTEOARTHRITIS OF THE TRAPEZIO-METACARPAL JOINT

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Osteoarthritis of the trapezio-metacarpal joint may be monarticular and probably is often traumatic in origin. Table I is an analysis of fifteen patients with disability severe enough to justify operation. The series is small because the condition is not very common. It is found in later life and mainly in women. The right side is more often affected than the left but both joints are sometimes involved. The figure for bilateral cases rather underestimates the frequency, a few other patients had slight symptoms on the opposite side not severe enough to require operation. Although there was a history of injury in only a third of the patients, there may have been unremembered injuries in others, and it is probable that injury is one of the main factors in causation. More than half of the patients were under the age of sixty and therefore required painless use of the thumbs for active work.

TABLE I

Number of patients	15
Number of trapezii excised	18
Sex—Male	5
Female	10
Age—Under 40 years	0
40–50 years	4
50–60	4
60–70	5
70–80	2
Side—Right	7
Left	5
Bilateral	3
General arthritic changes	2
History of injury	5

With regard to treatment, palliative measures cannot restore the articular surfaces, while arthrodesis of the joint is not easy, requires prolonged after-treatment and limits movement of the thumb. Removal of the trapezium is a simple form of arthroplasty and the results of this operation will be discussed.

Clinical features—All the patients complained of pain about the base of the thumb, especially on movement. There was usually some obvious swelling and in four cases a diagnosis of ganglion had been made. Movement of the joint caused pain and crepitus could often be felt.

Radiographic appearances—Loss of joint space was associated with one or more of the following changes: simple osteophyte formation (Fig. 1), radial subluxation of the metacarpal bone (Fig. 2), or small ossicles about the joint (Fig. 3).

TECHNIQUE OF OPERATION

With a tourniquet applied, an incision is made parallel to extensor brevis pollicis in the distal part of the anatomical snuff box. The joint between the trapezium and first metacarpal is easily identified and opened widely, it may be found distended with fluid. Damage to the last part of the radial artery where it crosses the trapezium on its way to the deep palmar arch must be avoided. The ligaments are dissected off the bone in a proximal direction till the articulation with the scaphoid is reached. A raspatory is then inserted into this joint to retract and protect the artery while the articulations with the trapezoid and second metacarpal bones are defined. In working round the palmar surface and dissecting off the transverse carpal ligament it is important to keep close to the bone, or the tendon of flexor carpi radialis may be damaged in its groove in the trapezium. With careful dissection, using a small bladed knife the tendon should not be seen during the operation. Even when all the attachments of the bone have apparently been separated, it may be disinclined to

* *Paper read at the Annual Meeting of the British Orthopaedic Association, 1948*

come out The temptation to lever the bone out forcibly must be resisted lest some fragments be left behind Examination of the trapezium after removal shows loss of the articular cartilage with eburnation of the bone, in some cases the articular surface is grooved from long-standing subluxation

Post-operative treatment—A firm pressure bandage is applied before removal of the tourniquet, but care is taken to avoid restriction of movements of the thumb Active movements are started at once Because of pain, many of these patients have long avoided movement of the first carpo-metacarpal joint and supervision is necessary to see that the thumb is moved through a full range

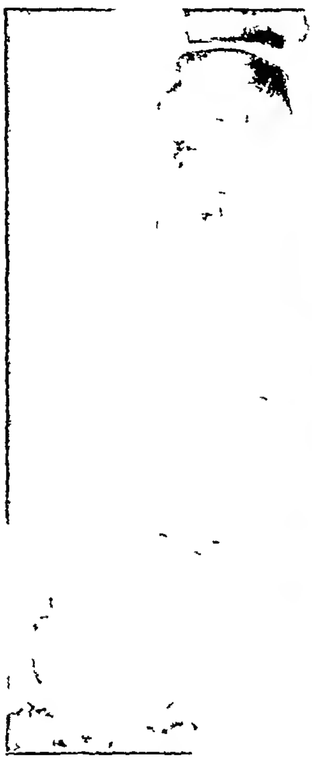

FIG 1

FIG 2

FIG 3

Characteristic radiographic appearances of osteoarthritis of the trapezio-metacarpal joint Loss of joint space is associated with osteophyte formation (Fig 1), subluxation (Fig 2) or formation of discrete ossicles (Fig 3)

RESULTS

There are two patients in the series in whom the results are inferior and both show general arthritic changes The first is the only patient who is not glad to have had th operation She was aged seventy-one years and had generalised osteoarthritic change especially of the knees, to some extent of the hands, and slightly in the righ trapezio-metacarpal joint The left trapezium was excised a year ago on account c considerable pain on that side Now there is full and painless movement of the first metacarp bone and in this respect function is greatly improved But the arthritic changes in the fing have increased with wasting of the intrinsic muscles, so that the function of the hand as whole has deteriorated

The second patient was aged fifty-four years and had pain from severe osteoarthritis both trapezio-metacarpal joints with marked subluxation There were mild arthritic chan in the wrists and fingers, more of the rheumatoid type Both right and left trapezia we removed and, though movements of the first metacarpal bones are now free and painl

there are slight effusions into the wrist joints and the patient complains that the thumbs are still weak

The results in the remaining cases have been uniformly good. Two patients were operated upon early in 1944. One was a seamstress aged forty-six years, with increasing pain in the right thumb and difficulty in her work over a period of four years. She returned to full work after three weeks and the joint remains free from pain. Radiographs show a fragment of bone that has formed a small trapezium, but this does not seem to impair the function of the arthroplasty. The other patient was aged fifty-eight years, the left thumb was affected and the radiographs showed small discrete ossicles (Fig 3). She has written to say that some time elapsed before she recovered efficient use of the thumb which is now quite satisfactory.

The next patient, seen in 1945, was a farm worker aged forty-eight years, who had suffered for some years from pain in his right thumb which he dated from an injury. He resumed farm work two months after operation, but returned in 1947 complaining of the left thumb, which showed severe osteoarthritis. The trapezium on this side was removed, he has been doing full farm work ever since and is free from pain. Figure 4 shows the condition of the right thumb four years after operation. Another patient seen in 1945 was a woman aged fifty-three years with bilateral changes. Both trapezia were excised. She is very satisfied, but states that there is some weakness in the thumbs for such a movement as turning a tap.

The next patient was seen in 1946, a man complaining of pain and diminished movement of his right thumb. At that time he was a night watchman, but now does full work in the kitchen of a restaurant. Another patient operated upon in that year was a cowman aged forty-nine years who was unable to work because of severe pain in his right thumb (Fig 2). One month after operation he was milking twenty cows a day.

FIG 4

The right wrist of a man aged forty-eight years taken four years after operation. The left trapezium was subsequently removed and he has returned to full farm work.

In more recent cases the results have continued to be satisfactory though older patients tend to be slow in gaining full recovery.

SUMMARY

1 The technique of excision of the trapezium for osteoarthritis of the trapezio-metacarpal joint is described

2 The results of eighteen operations in fifteen patients are analysed

3 The operation is of value particularly when the arthritis is monarticular. Results have been less satisfactory when the affection of the joint is part of a generalised arthritis

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ARTHRODESIS OF THE TRAPEZIO-METACARPAL JOINT FOR OSTEOARTHRITIS

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Painful osteoarthritis of the trapezio-metacarpal joint may result from occupation involving repetitive use of the thumb Mild symptoms are common in middle-aged women but advanced changes may be found in factory workers and particularly in those doing heavy sewing such as upholstery or mattress-making In severe cases the thumb is held adducted and is used with caution, grasping, pinching and wringing movements are uncomfortable, and the lifting of heavy objects requiring a wide grip causes much pain

Examination shows some swelling and local tenderness from synovial and capsular thickening Abduction and extension movements are limited and opposition is carried out with difficulty Thus for a pincer grip the pulp of the thumb is applied to the distal joint of the index, whereas normally both tips meet to form an " O " in a position of great strength of the thumb In addition to sclerosis of the subchondral bone and osteophytic lipping, radiographs often show a small detached osteophyte on the lateral aspect of the joint at the site of maximum tenderness

FIG 1

To illustrate the technique of arthrodesis of the trapezio metacarpal joint

FIG 2

To show sound arthrod... with a bone graft f... the ilium (Case 3)

Arthrodesis of the joint and excision of the trapezium (Gervis 1948) are two methods of dealing with the more severe cases A sound arthrodesis retains the stability and power of the thumb, and the continuity of the line of bones from the radius through the scaphoid and trapezium to the first metacarpal being intact, the system is not deprived of one of its units of leverage A case of " failed arthrodesis " can be treated by a second graft if symptoms continue, whereas grafting after " failed excision " of the trapezium must be difficult One disadvantage is some difficulty in obtaining sound fusion because the subchondral bone of the trapezium is sclerotic and there is little enough of the bone left after complete excision of the articul... surface Post-operative fixation must therefore be efficient and prolonged Anoth... disadvantage is the need for a separate incision over the tibia or ilium to obtain a b... graft of good quality There is no doubt that a graft is essential for the reason that sim... excision of the joint gives rise to fibrous ankylosis

Technique of arthrodesis—The bones are exposed from the lateral subcutaneous as... and the insertion of extensor ossis metacarpi pollicis is elevated A narrow slot is cut in ... first metacarpal and trapezium, in this way the alignment of the bones is not alt... subsequently The accessible capsule, the synovial membrane of the trapezio metacar...

joint, and then the joint surfaces are excised, particular attention is paid to the medial part of the saddle-shaped surface of the trapezium which is difficult of access The bones having been fitted together accurately, the graft is skidded into the slot and tightly impacted (Fig 1)

Source of the graft—In one case the oblong of metacarpal shaft raised from the slot was used as a sliding graft but the quality of the bone was poor Tibial grafts were used in four cases, one bilateral case operated upon by a colleague for the second side ended with a pseudarthrosis The last three cases have had iliac grafts including some cortical bone cut with a finger chisel in one piece from the crest A few cancellous chips have supplemented the main graft The greater osteoblastic activity and elasticity of iliac bone make it superior to tibial bone for this purpose

After-care—The thumb and wrist are fixed in a scaphoid type of plaster with the thumb in mid-opposition, and the limb is elevated for a few days After two or three weeks a well-fitting cast is applied over stockinette and immobilisation is continued for a total of at least four months When iliac bone is used even longer may be required despite the radiographic appearances In two recent cases the plaster was removed after four months, when there was no tenderness locally or pain on springing the bones and when the radiographs seemed satisfactory, but within a week pain and tenderness recurred and fixation had to be resumed

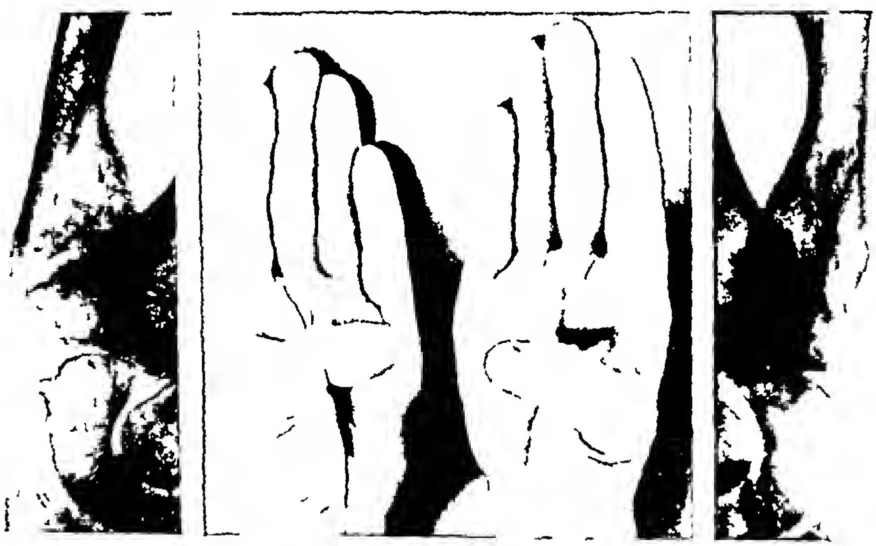

FIG 3

Case 4 To show the range of opposition after operations resulting in fibrous ankylosis of the left trapezio metacarpal joint and sound fusion of the right joint

Results—Eight operations have been carried out on seven patients Six joints fused soundly and gave excellent and painless *function* One patient remains untraced In one bilateral case for which tibial grafts were used, the right side gave a sound arthrodesis but the left side, operated on two years later, ended with fibrous ankylosis (*Fig* 3) At review four years after the second operation this patient said there was no difference in function between the two sides, she was working again as a draper's assistant, gripping heavy rolls of cloth between each thumb and forefinger with no loss of power

CASE REPORTS

Case 1 Mrs F S aged fifty-eight years housekeeper—*Pain and swelling in right thumb for five months increasing in severity* Arthrodesis with sliding metacarpal graft March 1943 Plaster removed after four months fusion solid *Good function subsequently*

Case 2 R S aged thirty-two years, tank mechanic—Blow on base of left thumb three years previously Radiographs showed unusual prominence of the base of the first metacarpal and a distorted trapezium with osteoarthritis in the carpo-metacarpal joint Arthrodesis with tibial graft August 1945 Plaster removed after five months good function regained within a fortnight

Case 3 Mrs H S aged fifty-eight years factory worker—Pain in the joint since changing one type of work for another both types involving repetitive thumb movements Arthrodesis with iliac graft June 1948 (Fig 2) Plaster removed after five months early return of full function Now able to touch the basal crease of the little finger with the tip of the thumb free from pain and very pleased with the result

Case 4 Mrs E M aged fifty-three years draper s assistant—Long-standing pain in both thumbs worse on the right side Right side grafted in October 1943 with tibial bone Plaster for five months and sound arthrodesis Left side operated on in January 1945 again with a tibial graft Pseudarthrosis occurred on this side When seen in June 1948, the patient was pleased with both results and there was no difference in function or movement She was able to oppose each thumb to the proximal phalanx of the little finger (Fig 3)

Case 5 Mrs B L aged forty-two years upholsterer—Severe symptoms in left thumb for two years Arthrodesis with iliac graft in May 1948 Plaster for five months full painless movement soon after Able to oppose tip of thumb to basal crease of little finger

Case 6 Mrs A C aged fifty-one years housewife—Arthrodesis with a tibial graft in December 1944 Patient cannot be traced

Case 7 Mrs P C aged fifty-seven years housewife—Symptoms in left thumb for two years Arthrodesis in July 1947 with iliac bone One year later painless and excellent function

Comment—Apart from the relief of pain given by the fusion the most striking feature of these cases is the early return of function after removal of the plaster cast Arthrodesis of the trapezio-metacarpal joint scarcely affects the range of movement of the thumb, probably because of the compensatory increase in the range of the trapezio-carpal joints

I am indebted to Mr B H Burns for permission to report five cases and for his stimulating interest, to Mr V H Ellis for a further case and to Mr R T Whitley of the Institute of Orthopaedics for the prints of the radiographs

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A CONGENITAL ABNORMALITY OF THE TRAPEZIUM AND FIRST METACARPAL BONE

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Congenital abnormalities of the trapezium are uncommon. In this patient the trapezium and the base of the first metacarpal were affected on both sides.

Case history—Mrs L. E., aged sixty-five, attended for a painful exostosis of the foot, but it was noticed that both hands were abnormal. She stated that the base of each thumb had been deformed since childhood; there was no history of injury and no relevant family history. The condition caused little inconvenience, though she had noticed that the range of movement was less than normal and had diminished with advancing years. She was able to carry out her household duties without pain.

FIG. 1

The dorsal aspect of the patient's hands. Note the prominence of the base of each first metacarpal.

Examination—On each side there was marked prominence of the base of the first metacarpal (Fig. 1). There was no wasting of the thenar muscles and no local tenderness. The range of movement at the carpo-metacarpal joint was limited, particularly abduction and extension. Opposition, however, was almost normal. The metacarpo-phalangeal joint was unusually mobile. Apart from hallux valgus, no other abnormality was discovered.

The radiographs showed that the abnormality was almost symmetrical, and consisted of enlargement of the base of the metacarpal and gross alteration in shape of the trapezium, which was longer than normal and presented an acute angle on the radial aspect (Figs. 2, 3). Each trapezio-metacarpal joint was deformed. There was a separate ossicle in each hand, on the right at the outer angle of the trapezium forming part of the joint surface, and on the left on the palmar surface, seen more clearly in the lateral radiograph in the position of the tuberosity. The trapezio-metacarpal joints were obviously arthritic with narrowed joint spaces, but were also distorted as if they had migrated proximally.

Review of the literature—Pfitzner (1895) produced a plan of the hand showing the numerous cartilaginous centres which could occur in the embryo and which might persist as

FIG 2
Antero-posterior and lateral radiographs of the right hand

FIG 3
Antero-posterior and lateral views of the left hand

separate bones in the adult In relation to the trapezium there are four centres (Fig 4) On the dorsal aspect there are the *epitrapezium* next the scaphoid, the *paratrapezium* at the outer angle, and the *secondary trapezium* at the distal angle between the first a second metacarpals On the palmar surface the *praetrapezium* is at the distal end of t tuberosity Pfitzner doubted for a time whether the secondary trapezium really d exist Dwight (1907) in a monograph on accessory bones stated that he had seen a praetrapezium in a pair of hands and that the epitrapezium had been reported or He had not seen a paratrapezium but had found a secondary trapezium as a distr bone once He had seen the secondary trapezium simulated a few times in c

with deformity of the first metacarpal and flattening of the trapezio-metacarpal joint, but he considered these cases pathological and did not reproduce the radiographs

In a critical review of Pfitzner's plan Grumbach (1921) ascribed most of these accessory bones to injury, with the possible exception of the epitrapezium Kohler (1928) and Bogart (1932) had seen no accessory trapezium elements Brailsford in 1936 showed radiographs of a foundry worker similar to those of the present patient In a private communication (1949) he stressed his conception of the etiology as that of repeated injury with resulting osteoarthritis

Gruber (1875) found a patient with a praetrapezium in each hand Cuyer (1887) described an ossicle in the position of the paratrapezium articulating with the first metacarpal (Fig 5) He did not note any alteration in the metacarpal but his drawing suggests that the joint surface was longer than normal Heimerzheim (1925) mentions a case similar to Cuyer's In a study of inherited brachydactyly in a New Zealand family, Nissen (1933) found ten adults and one child with accessory carpal bones which included a praetrapezium in two instances

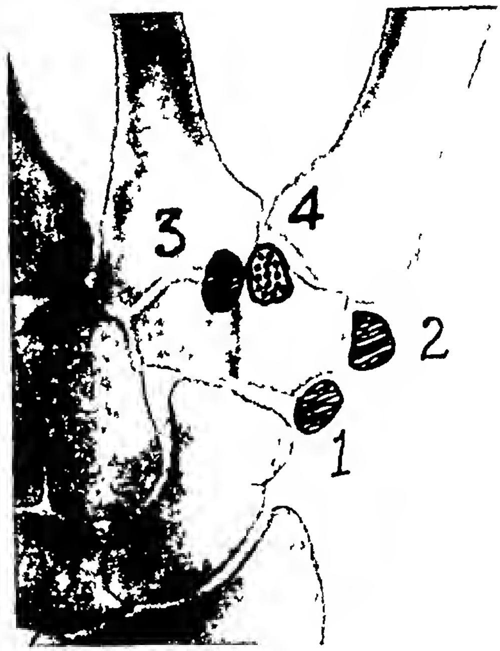

FIG 4

A diagram of the accessory centres of the trapezium from the dorsal aspect (1) the epitrapezium (2) the paratrapezium, and (3) the secondary trapezium The praetrapezium (4) is on the palmar aspect

Osteoarthritis of the trapezio-metacarpal joint with loose body formation is well recognised (Gervis 1948) This condition, however, gives rise to pain and disability whereas accessory bones seldom cause symptoms Bennett's fracture-dislocation of the thumb may lead to secondary osteoarthritis, but the history is usually clear Fusion of the trapezium with other carpal bones is very unusual The only cases described are of fusion of the trapezium and scaphoid (Turner 1883 and Gougerot 1905)

Discussion—No doubt some of the previous writers would have ascribed the changes in this case to injury The deformity, however, was noticed at an early age, and as it is bilateral and nearly symmetrical, must be regarded as congenital

According to Pfitzner's plan, the trapezium at one stage may consist of a main centre and four minor cartilaginous centres which may persist and alter the shape of the bone The secondary trapezium centre would enlarge the distal part of the bone between the first and second metacarpals and would tend to displace the trapezio-metacarpal joint surface proximally, while a persistent paratrapezium centre would enlarge the outer angle of the bone The shape of the trapezium in this patient could thus be produced It is significant that on the right side there is a paratrapezium similar to those described by Cuyer and by

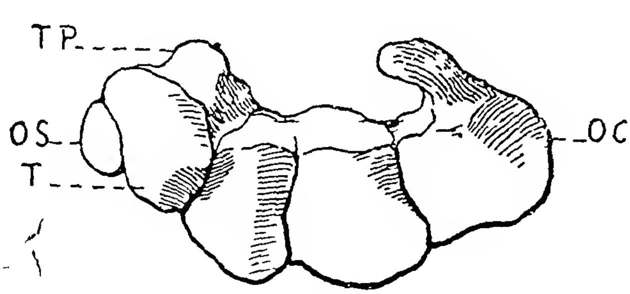

FIG 5

The paratrapezium after Cuyer The drawing shows the distal aspect of the carpus T=trapezium O S=paratrapezium, O C=unciform bone

Heimerzheim, and that on the left side the ossicle is in the position of a praetrapezium The abnormality of the metacarpal could well arise as a feature secondary to the deformation of the trapezium in its cartilaginous state This explanation accords with the review of the literature

SUMMARY

A bilateral congenital abnormality of the trapezium and first metacarpal is described The condition may be related to abnormal ossification of the trapezium in accordance with Pfitzner's plan It is quite distinct from osteoarthritis of the trapezio-metacarpal joints

My thanks are due to Mr A T Fripp for permission to publish this case and to Mr R J Whitley for assistance with the illustrations

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VARIATION IN EXTENSION OF THE METACARPO-PHALANGEAL AND INTERPHALANGEAL JOINTS OF THE THUMB

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Variation in the range of movement of different joints has often been studied by special instruments, so fitted to the limbs that they give direct readings Radiographic methods have also been used but are often unsuitable when there is movement in more than one plane For a hinge joint, true lateral radiographs can be used to give the angle between the two bones, provided that a suitable long axis can be chosen for each bone

The range of extension movement of the thumb joints in the two authors of this contribution was found to be strikingly different (Figs 2 and 3) and it was thought that a study of such variations in a random sample of the European population might be of interest Some so-called "double-jointed" individuals can hyperextend the metacarpo-phalangeal joint of the thumb, and the incidence, variation and mechanism of such hyperextension were investigated Extension of the joints of the thumbs was also measured in a number of Indians and West Africans in order to determine any racial differences

MATERIAL AND METHOD

The students and staff of the Department of Anatomy were the main sources of our European samples, 133 male and 100 female Europeans, 31 male Indians and 30 male West Africans formed the several groups In each subject a lateral view of the thumbs was taken with the metacarpo-phalangeal and interphalangeal joints extended fully The carpo-metacarpal joint was extended fully, with the thumb midway between abduction and adduction and the thumb-nail at right angles to the film

Standard longitudinal axes for the three bones had to be found on the radiographs In a lateral view of the thumb the posterior surfaces of the metacarpal and proximal phalanx usually present straight lines which can be used as axes (Fig 2) Sometimes the proximal phalanx does not show a well-defined straight line posteriorly, but in such cases a line may be drawn parallel to the greatest thickness of the cortical bone

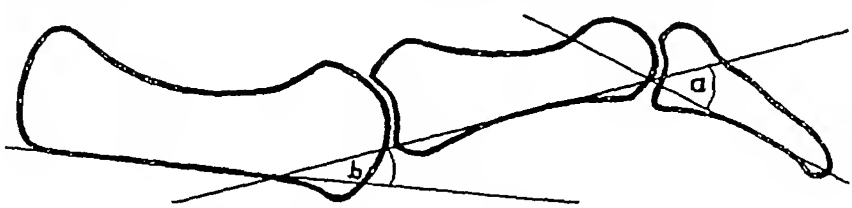

Fig 1

The method used for measuring the interphalangeal and metacarpo-phalangeal angles

The axis for the curved distal phalanx was more difficult to determine since the phalanx is always curved in a posterior direction However, there is nearly always a straight line of cortical bone about one millimetre wide on the posterior aspect, and a line drawn on the posterior surface of the phalanx parallel to this was chosen as the axis It might be argued that the greater the curvature of the distal phalanx the greater should be the angle between it and the middle phalanx It was found, however, that the curvature did not vary enough to affect the results materially

Once the axes were drawn, the angles between them were measured to the nearest half degree When the two axes were parallel or in line, the angle of course was zero A positive angle represented the number of degrees of extension beyond this position, if the axes did not reach this position, the angle was expressed as a negative figure (Fig 1)

TABLE I

ANGLES AT INTERPHALANGEAL AND METACARPO-PHALANGEAL THUMB JOINTS RECORDED BY TWO OBSERVERS MEASURING EACH ANGLE THREE TIMES

Joint	Subject	Observer I			Observer II		
		a	*b*	*c*	*a*	*b*	*c*
Right I -P	1	36	36 5	36 5	40	38	41
	6	23	23	22	22	22	21 5
	7	1	0	1	2	9	2
	8	29	30	27	28 5	30	29
	9	70	71 5	70	68 5	73	73
Right M -P	1	26 5	24 5	26	26	25 5	25
	6	24	23 5	23 5	24	23	23
	7	3	4	3	2	3	3
	8	0	1	0	0	0	5
	9	−8	−8	−8	−7 5	−8	−6 5
Left I -P	1	62	61 5	62	61	62	62 5
	6	10	13	14	11	10	11
	7	7	7	7 5	13 5	10	10
	8	36	36	36	34	35	35
	9	46	50	47	49	50 5	50
Left M -P	1	24	24 5	25	26	25	25
	6	8	8	9	8	7	8
	7	6	8	5	8	7	6
	8	14	14	14	14 5	14	14
	9	45	46	45	46	46	46

TABLE II

ANGLES AT INTERPHALANGEAL AND METACARPO-PHALANGEAL THUMB JOINTS OF TEN SUBJECTS EACH RADIOGRAPHED AGAIN AFTER AN INTERVAL

Subject	Right I -P		Right M -P		Left I -P		Left M -P	
1	60	63	26	27	61	62 5	25	28
2	16	17	9	4 5	21	15 5	11	9
8	28 5	33 5	0	1	35	32	14	6
11	25	26	16	17	35	35	21	18
13	42	42 5	0	0	33 5	31	1 5	4
15	30 5	28	11 5	11 5	41	41	−1 5	0
16	29	29	3 5	3 5	34	33	15	11
18	48	53	16 5	19 5	58 5	68 5	5	7 5
19	29	30	3	5 5	27	31 5	20	22
20	10	11	5	3	6 5	4	5	2 5

TABLE III

MEAN AND STANDARD DEVIATIONS OF THE ANGLES AT THE INTERPHALANGEAL THUMB JOINTS OF THE EUROPEAN GROUP

Sex	Side	Mean	Standard deviation	Number of observations
Male	Right	29 16	11 65	133
	Left	32 20	11 09	133
Female	Right	23 55	9 73	100
	Left	24 85	11 40	100

In view of the possibility of variation in the observers' interpretation and readings, two observers made three separate readings on radiographs of five subjects (*a*, *b* and *c* of Table I) In order to determine the variation in radiographic technique, ten subjects were radiographed twice with an interval between each film The results are shown in Tables I and II It was found that these possible errors were of the order of $\pm 2.5°$ and quite small as compared with the differences in the angles found in various subjects

Many of the subjects could produce further extension of the metacarpo-phalangeal joint when the carpo-metacarpal joint was flexed, in such cases a film was taken of the thumb in what will be referred to as the "second position" (Figs 4–7)

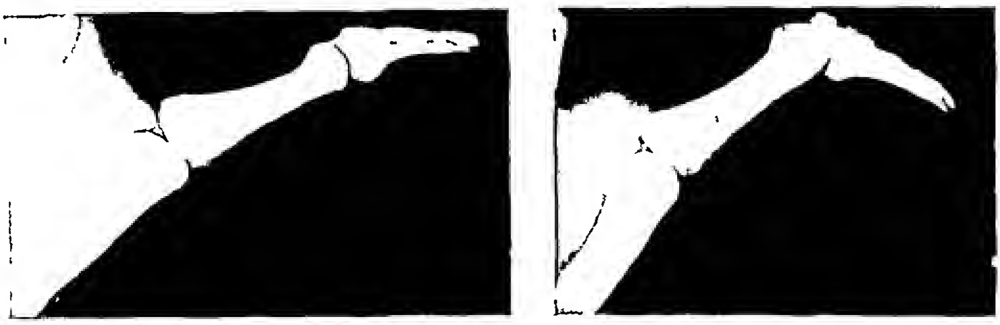

FIG 2 FIG 3

To show the range of extension movement of the thumb joints in the two authors

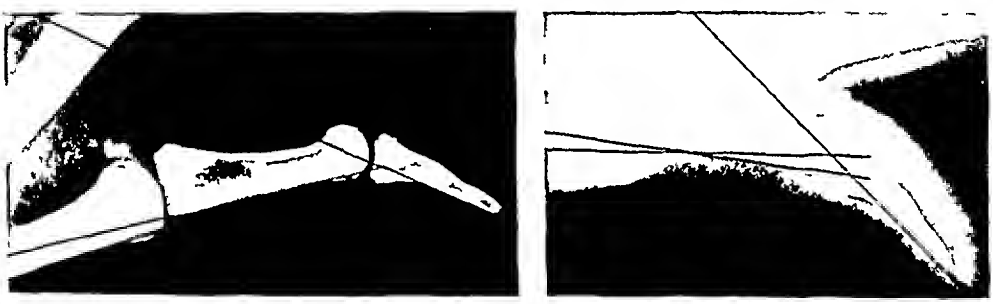

FIG 4 FIG 5

Figures 4 and 5 show the common finding, that no further extension of the metacarpo-phalangeal joint occurs when the carpo-metacarpal joint is flexed

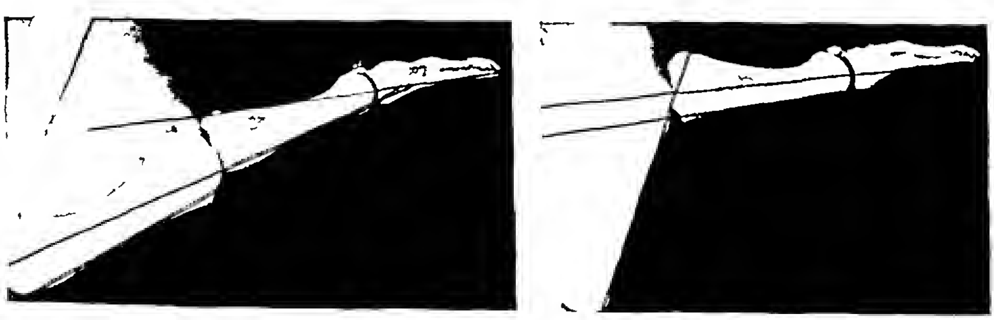

FIG 6 FIG 7

Figures 6 and 7 show that in some subjects further extension of the metacarpo-phalangeal joint occurs when the carpo-metacarpal joint is flexed

RESULTS

1) **Interphalangeal joints**—Figure 8 shows histograms of the angles at maximum extension of the interphalangeal joints of the right and left thumbs in European males and females Certain conclusions can be drawn

a) There is considerable individual variation, the greatest angle observed was 67.5° and the smallest 0°

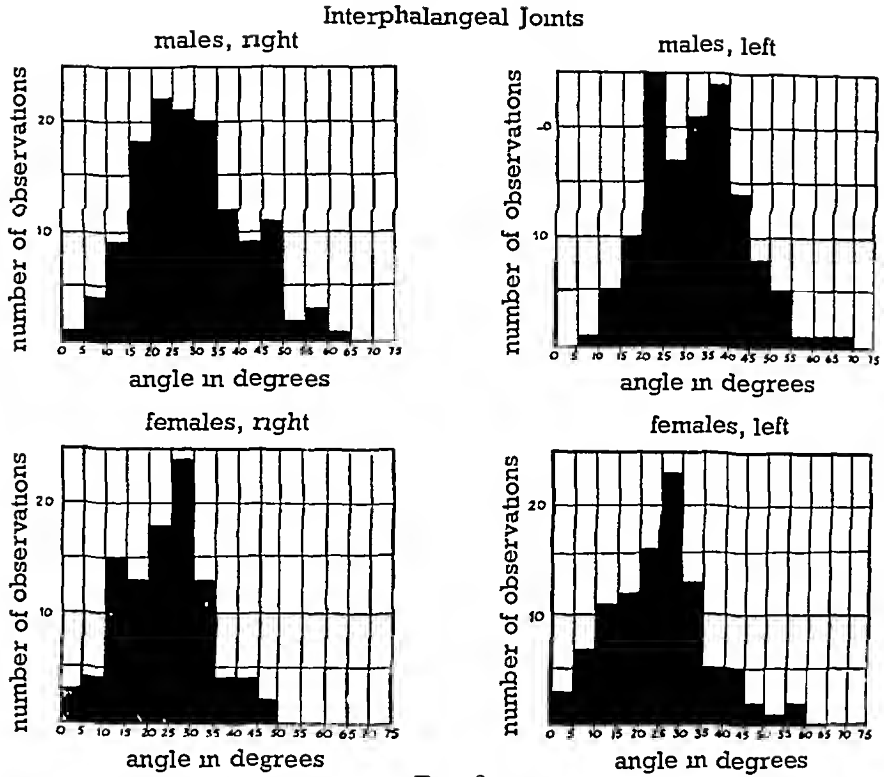

FIG 8

Histograms of angles of maximum extension at the interphalangeal joints of the right and left thumbs in males and females

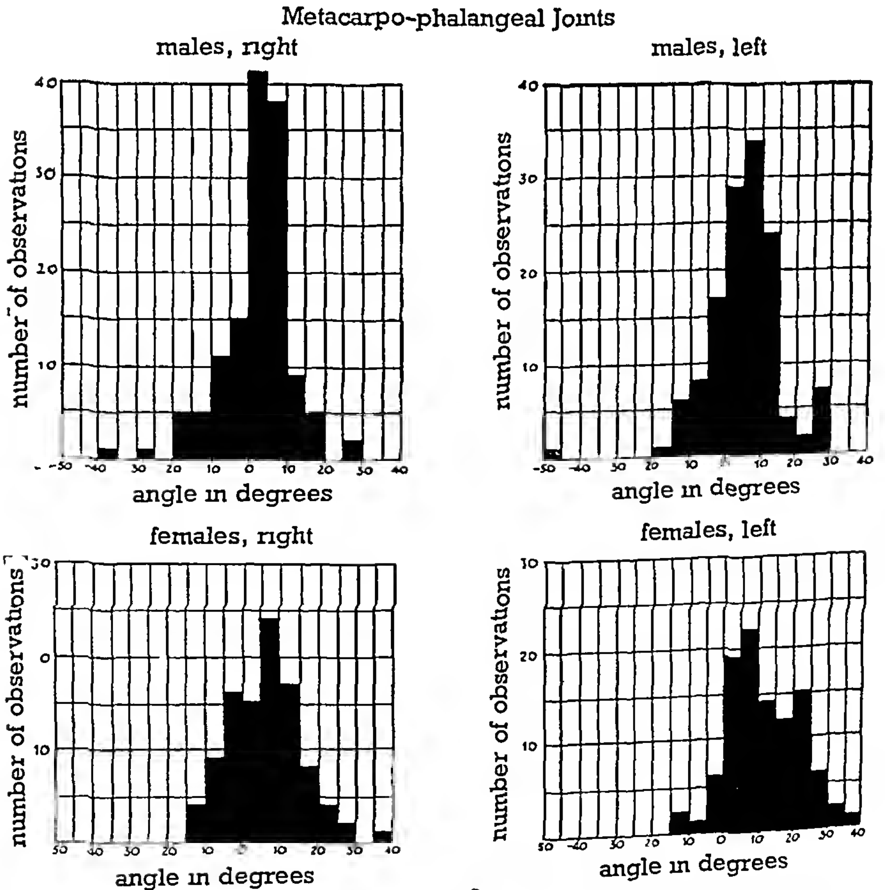

FIG 9

Histograms of angles of maximum extension at the metacarpo phalangeal joints (first position) of the right and left thumbs in males and females

b) The distribution is fairly symmetrical, the means and standard deviations of the angles for the right and left sides in both sexes are given in Table III

c) In the males the mean of the right is 3 01° greater than the mean of the left, this difference is barely significant In the females the difference between the right and left is certainly not significant

d) In both right and left thumbs the means in the males are significantly greater than those in the females

e) There is a high correlation between the right and left joints in both males and females (r=0 66 in the males and 0 81 in the females)

2) **Metacarpo-phalangeal joint**—Figure 9 shows histograms of the angles of maximum extension at the metacarpo-phalangeal joints of the right and left thumbs in European males and females The following conclusions can be drawn

a) There is considerable individual variation in maximum extension at this joint, the greatest angle observed was 34° and the smallest −48°

b) The distribution is fairly symmetrical, the means and standard deviations for the right and left sides in both sexes are given in Table IV

c) In the males the mean of the right is 3 30° greater than the mean of the left, and in the females it is 5 60° greater, these small differences are statistically significant

d) The mean of all the angles is small and the angle is often negative

e) In both right and left thumbs the mean for the females is significantly greater than the mean for the males

f) There is a high correlation in both sexes between right and left thumbs (r=0 59 in the males and 0 64 in the females)

TABLE IV

MEANS AND STANDARD DEVIATIONS OF THE ANGLES AT THE METACARPO PHALANGEAL JOINTS OF THE EUROPEAN GROUP

Sex	Side	Mean	Standard deviation	Number of observations
Male	Right	2 31	9 22	133
	Left	5 62	9 71	133
Female	Right	5 95	9 59	100
	Left	11 55	9 97	100

3) **The interphalangeal compared with the metacarpo-phalangeal joints**—The maximum extension at the interphalangeal joint may be related to the maximum extension in the "first position" at the metacarpo-phalangeal joint The correlations between the two joints in the right and left thumbs of the males and females were calculated and it was found that a slight negative correlation existed in all four cases (Table V) This means that, if the maximum extension angle at the interphalangeal joint is high, the maximum extension angle at the metacarpo-phalangeal joint tends to be correspondingly smaller

TABLE V

CORRELATIONS BETWEEN INTERPHALANGEAL AND METACARPO-PHALANGEAL JOINTS OF THE RIGHT AND LEFT THUMBS OF THE EUROPEAN GROUP

Side	Males		Females	
	r	Observations	r	Observations
Right	−0 19	133	−0 19	100
Left	−0 20	133	−0 10	100

TABLE VI

NUMBER OF SUBJECTS SHOWING AN ANGLE OF MORE THAN 40° AT THE METACARPO-PHALANGEAL JOINT IN THE "SECOND POSITION"

Sex	Right	Total examined	Left	Total examined
Male	5 (3 73%)	133	10 (7 5%)	133
Female	11 (11%)	100	18 (18%)	100

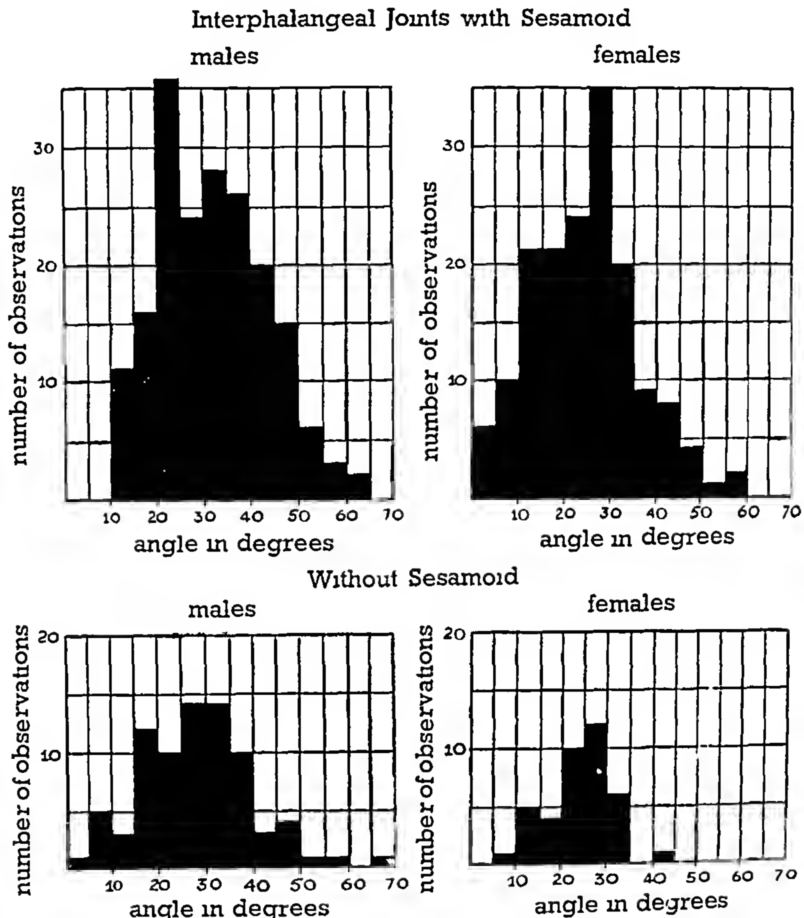

FIG 10

Histograms of angles of maximum extension at the interphalangeal joints of males and females with and without sesamoid bone

4) The "second position"—An examination of the films taken with the carpo-metacarpal joint in flexion showed that, although the angle at the interphalangeal joint showed no significant change from the "first position," there was sometimes a considerable increase in the angle at the metacarpo-phalangeal joint Some of these second positions could be described as subluxations (Fig 7) An attempt was made to select these cases by inspection of the radiographs It was found, however, that no sharp distinction could be drawn, either from the appearances or from measurements of the metacarpo-phalangeal angles, between extreme extension of the joint and subluxation Extreme extension, or subluxation, was seen more often in women and more often in the left hand This is shown in Table VI, which gives the number of cases showing an angle of more than 40° This particular angle was chosen because such a high value was never obtained in the "first position"

5) The relation between extension at the interphalangeal joint and the presence of a sesamoid bone—Figure 10 gives the histograms of the distribution of the angles at the interphalangeal joints of the thumbs in males and females with and without a sesamoid bone

TABLE VII

MEANS AND STANDARD DEVIATIONS OF ANGLES AT THE INTERPHALANGEAL JOINTS WITH AND WITHOUT A SESAMOID BONE

Sex	With sesamoid			Without sesamoid		
	Mean	Standard deviation	Number of observations	Mean	Standard deviation	Number of observations
Male	31 80	11 40	187	28 14	12 05	79
Female	24 17	11 34	161	23 90	7 05	39

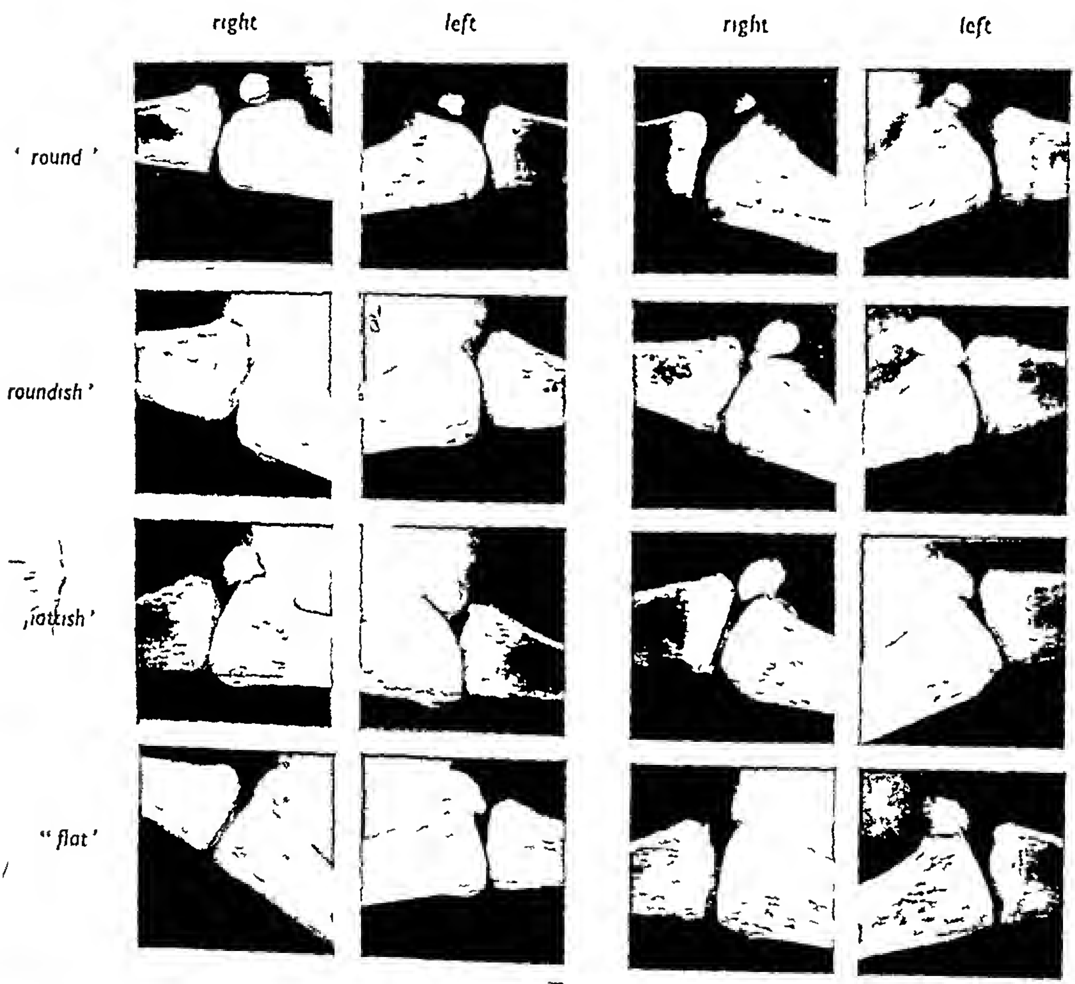

FIG 11

Variations in the shape of the head of the first metacarpal bone

Table VII gives the means and standard deviations of the angles with and without a sesamoid bone The distributions are clearly very similar and the difference between the means cannot be regarded as significant

b) **Shape of the head of the metacarpal bone**—The shape of the metacarpo-phalangeal joint surfaces varies considerably between " round " and " flat " It was easier to divide the joints into four groups according to the shape of the metacarpal heads " round," " roundish," " flattish " and " flat " (Fig 11)

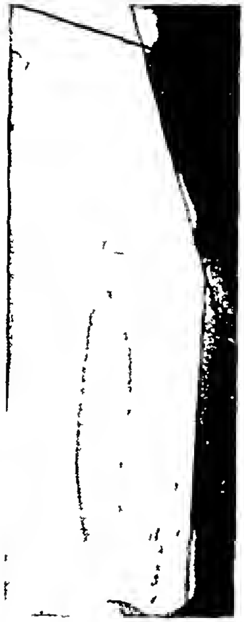

FIG 12 FIG 13

To show the difference in range of flexion at the metacarpo-phalangeal joint when the articular surfaces are round or flat in type

Certain conclusions can be drawn about the association between the shape of this joint and its movements

a) The right and left thumbs usually have the same type of joint

b) In flat joints, increased extension in the "second position" is not found

c) A preliminary survey of flexion at the metacarpo-phalangeal joints suggests that in "flat" and "flattish" joints flexion is considerably limited (Figs 12 and 13)

d) The combined incidence of "flat" and "flattish" joints is about 10 per cent

7) *Group of 31 male Indians compared with 133 male Europeans*—Figure 14 shows histograms of the angles of maximum extension at the interphalangeal and metacarpo-phalangeal joints in the "first position" of the right and left thumbs, and Table VIII shows the means and standard deviations for these joints in the Indians The following conclusions can be drawn *a*) As in Europeans, both joints show a considerable variation between individuals in maximum extension in the "first position," and the distribution is fairly symmetrical *b*) The means of the right and left interphalangeal joints are greater by 7 54° and 7 56° respectively in Indians than in Europeans, these differences are statistically significant

TABLE VIII

MEAN AND STANDARD DEVIATIONS OF THE ANGLES AT THE INTERPHALANGEAL AND METACARPO-PHALANGEAL JOINTS IN THE INDIAN GROUP

Side	Mean	Standard deviation	Number of observations
Right	36 69	15 51	31
Left	39 76	11 45	31
Right	2 20	11 98	31
Left	10 08	13 68	31

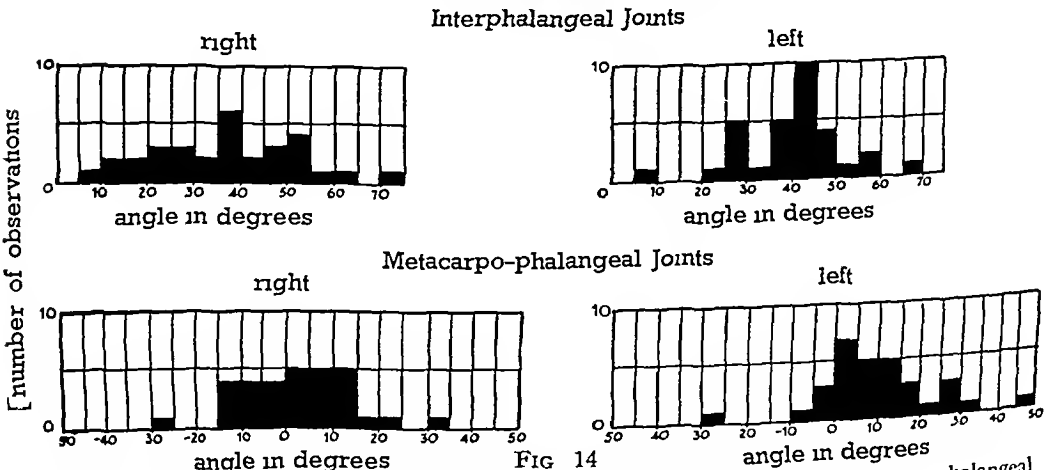

FIG 14

Histograms of angles of maximum extension at the interphalangeal and metacarpo phalangeal joints of the right and left thumbs in 31 male Indians

c) The mean of the right metacarpo-phalangeal joint in Indians is 0 12° less, and the mean of the left metacarpo-phalangeal joint is 4 46° greater, than the means of the corresponding joints in Europeans, neither of these differences is significant

d) The Indians show a significant increase in the number who have a hyperextended "second position," that is, over 40° 16 out of 62 Indian thumbs show this as compared with 15 out of 266 European thumbs

8) Group of 30 male Africans compared with 133 male Europeans—Figure 15 shows histograms of the angles of maximum extension at the interphalangeal and metacarpo-phalangeal joints in the "first position" of the right and left thumbs, and Table IX the means and standard deviations for these joints in Africans The following conclusions can be drawn

a) As in Europeans, both joints show considerable variation between individuals in maximum extension in the "first position," and the distribution is fairly symmetrical

b) The means of the right and left interphalangeal joints are greater by 7 35° and 10 13° respectively than the corresponding means in Europeans, these differences are statistically significant In this respect the Indians resemble the Africans

c) The means of the angles at the right and left metacarpo-phalangeal joints in Africans are 0 15° and 0 12° respectively less than the corresponding means in Europeans, neither of these differences is significant

d) Out of a total of 60 metacarpo-phalangeal joints there are 4 which can be grouped as hyperextensors, that is, measuring over 40° in the "second position" This proportion is much less than in Indians but similar to that found in Europeans

TABLE IX

MEANS AND STANDARD DEVIATIONS OF THE ANGLES AT THE INTERPHALANGEAL AND METACARPO-PHALANGEAL JOINTS IN THE AFRICAN GROUP

Side	Mean	Standard deviation	Number of observations
Right	36 50	13 15	30
Left	42 33	11 45	30
Right	2 17	10 57	30
Left	5 50	9 85	30

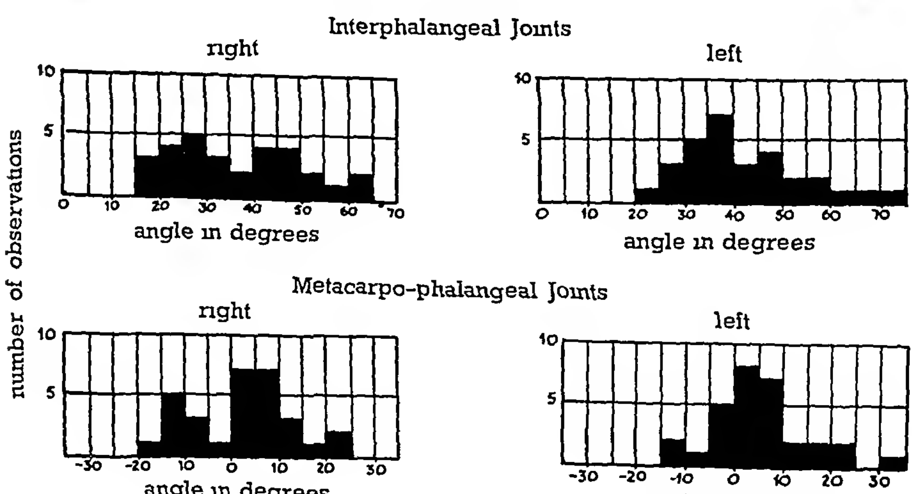

FIG 15

Histograms of angles of maximum extension at the interphalangeal and metacarpo-phalangeal joints of the right and left thumbs in 30 male Africans

DISCUSSION

Interphalangeal joint of the thumb—There is very wide variation in the range of extension movement in this joint In a normal joint the range of movement is determined by the shape of the articular surfaces, by the capsule and ligaments, by the associated muscles and tendons and by the fascia and skin related to the joint There is little variation in the shape of the articulating surfaces in different subjects, and it is probable that the observed variation is related to the capsule, to the muscles and tendons that produce the movements, or to both If the anterior capsule is lax, more extension may occur, and clinical examination gives the impression that this is the main factor Voluntary extension, however, may be influenced also by the ability of the flexor pollicis longus to lengthen and of the extensor pollicis longus to shorten If this were an important factor one might have expected a change in the range of extension of the interphalangeal joint when the thumb was held in the "second position" with the carpo-metacarpal joint flexed In most subjects, however, no such change was observed In a few, where in the "second position" there was a very pronounced degree of extension of the metacarpo-phalangeal joint, the flexor pollicis longus was so lengthened round the front of the metacarpo-phalangeal joint that extension at the interphalangeal joint was reduced (Figs 16 and 17) In many subjects with a large angle of extension at the interphalangeal joint of the thumb, there is evidence that the joints of the other digits can be hyperextended

There have been many investigations and many differences of opinion on the functions of the sesamoid bones of the hand (Gillette 1872, Pfitzner 1891-92, Retterer 1918) It has been shown in this study that whatever function they may have, the presence of sesamoid bones at the interphalangeal joint of the thumb is not related to the range of extension of that joint

Metacarpo-phalangeal joint of the thumb—Maximum extension here presents more problems The shape of the joint surfaces is probably important in determining the range of movement at the metacarpo-phalangeal joints because on no occasion was there an increase in extension in the "second position" in a joint classified as "flat" or "flattish" On the other hand, when the metacarpal head was "round" or "roundish," increase in extension in the "second position" was often found The term "hinge joint" in arthrology is somewhat misleading At most joints where hinge movements take place, gliding movements also occur If the surfaces between the bone ends are reciprocally curved, the range of movement is increased considerably If the joint surfaces are flat, one bone is incapable of gliding round the other, it simply tilts at the front or back edges of the joint, and increased flexion or extension demands wide separation of the joint surfaces and considerable stretching of the capsule Joints with flat surfaces are therefore associated with a limited range of movement

The large number of muscles attached to the region of the metacarpo-phalangeal joint makes it difficult to examine their role in determining the range of extension Only one muscle is attached near the back of the joint, namely extensor pollicis brevis It produces extension but it is aided at full extension of the interphalangeal joint by the extensor pollicis longus On the flexor aspect of the joint are abductor pollicis brevis, flexor pollicis brevis, the first palmar interosseous, the first dorsal interosseous, and the adductor pollicis transversus and obliquus In full extension all these muscles are stretched and, if they were short, limited extension might be expected A short flexor pollicis longus would also prevent full extension at this joint if the interphalangeal joint were fully extended

The capsule may be important because a tight anterior capsule could limit extension Another factor is the web between the thumb and index finger If the metacarpal bone is extended fully the web is usually taut and could limit extension of the metacarpo-phalangeal joint

FIG 16

FIG 17

To show that increased extension at the metacarpo-phalangeal joint may cause diminished extension at the interphalangeal joint

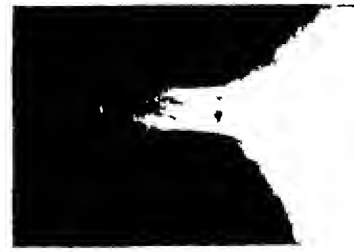

FIG 18

A hyperextensible thumb in a child of one of the subjects

If the carpo-metacarpal joint is flexed, further extension at the metacarpo-phalangeal joint does not usually take place This failure to extend further must be due either to the shape of the joint surfaces or to the tightness of the anterior capsule, because the muscles in front of the joint and the web are relaxed In a proportion of subjects with curved joint surfaces further extension does take place, and we suggest that laxity of the capsule is the reason The degree of further extension is variable but it can amount almost to subluxation of the joint

The word "double-jointed" is frequently used by laymen to describe individuals who can extend one or more joints excessively No dictionary or standard text-book of anatomy, however, contains the word It is clear that this ability to hyperextend is one of the phenomena referred to when the word "double-jointed" is used, but it is difficult to see what "double" signifies in this context Many of the subjects were well aware of their ability to hyperextend the metacarpo-phalangeal joint of the thumb It can be present from a very early age (Fig 18) Most subjects said that practice had not increased the amount of extension, one said that, having recognised the trick in one hand, she had learned by practice to do it with the other One or two remarked that the range of extension movement had decreased over a period of years

FIG 19

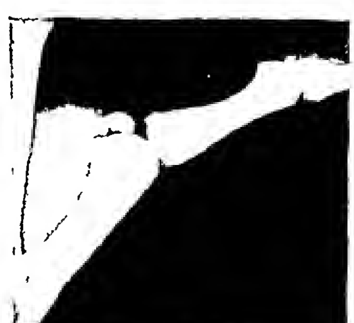

FIG 20

FIG 21

FIG 22

FIG 23

FIG 24

To show the sequence of movements in one subject with hyperextensible thumbs

Usually the movement was under complete voluntary control but occasionally attempt to extend the thumb fully were accompanied by sudden involuntary movement into t' hyperextended position, and one subject said this tendency to subluxate occurred wh spanning an octave on the piano

The sequence of movements is initiated by flexion of the carpo-metacarpal joint by t' flexor pollicis brevis, which may be accompanied by slight abduction of the metacarpal bon The extensor pollicis longus and extensor pollicis brevis are then contracted, thus pullu the proximal phalanx into further extension Beyond a certain point, it is the action of the muscles that produces full extension at the metacarpo-phalangeal joint (Figs 19-24)

In a genetical and linkage study of acholuric jaundice in twenty-six families, Race (194 noted the occurrence of hyperextensibility of the metacarpo-phalangeal joint This he defin

FIG 25

FIG 26

A subject with marked limitation of extension at the metacarpo-phalangeal joint of each thumb Note the peculiar shape of the metacarpal heads

FIG 27

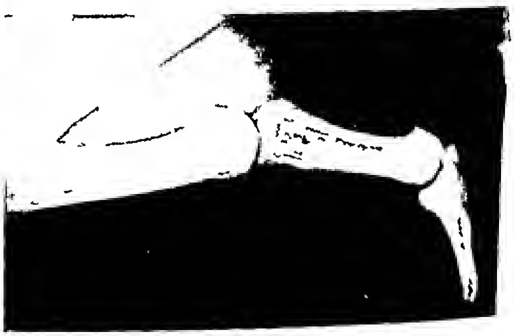

FIG 28

A subject with an unusual range of extension at the interphalangeal joint of each thumb

as " ability to extend this joint, undoubtedly beyond 180°," but his observations were clinical and not radiological He found that about 15 per cent of the individuals he studied could do this in one or other hand, though more often in the left than in the right From his dat it seems probable that the condition has a familial concentration, and a genetical factor ma be involved It is clear from our own studies, however, that this is not an " all or nor characteristic

Two subjects with unusual thumb movement—Two European subjects presei unusual features In one there was marked limitation of extension of the metacar phalangeal joints with increased extension at the interphalangeal joints (Figs 25 and 2 It was found that extension at the metacarpo-phalangeal joint was not increased even w the interphalangeal joint was fully flexed The shape of the metacarpal head was pecul It was uneven and suggested that the articular surface did not extend in a backward directi

more than half-way thus preventing full extension It was also possible that the front part of the capsule was very tight In the second subject (Figs 27 and 28) there was an unusually marked degree of extension at the interphalangeal joint, and considerable extension at the metacarpo-phalangeal joint, but no increase in this extension in the "second position" when the carpo-metacarpal joint was flexed Furthermore, he showed marked hyperextension of the joints of the rest of the digits The range of extension of the joints in this European subject was comparable only to that found in three Indians

Extension of the interphalangeal joint in Indians and Africans—The significant difference in extension at the interphalangeal joints between the Europeans on the one hand and the Indians and Africans on the other has already been commented on It is presumed that this is due to increased laxity of the capsule Compared with Africans a relatively large number of Indians can hyperextend their metacarpo-phalangeal joints, and in this respect the African group resembles closely the European group The increased extension in both joints of the thumbs in Indians is very striking, and is in conformity with the general impression that Indians, who make such use of joint movement in their national dancing, have indeed more mobile hands than Europeans

SUMMARY

1 The range of variation in full extension at the interphalangeal and metacarpo-phalangeal joints of the thumbs of 133 male and 100 female Europeans, and of 31 male Indians and 30 male Africans, has been investigated

2 There is considerable variation between individuals in the maximum extension of both joints of the right and left thumbs in all groups studied

3 The distribution for each joint in both thumbs in all groups is fairly symmetrical

4 There is a high correlation between the right and left thumbs for both joints in all groups

5 The mean angle of extension at the right and left metacarpo-phalangeal joints in all groups is similar Female Europeans, however, show a significantly greater mean angle than male Europeans

6 The mean interphalangeal angle of extension in male Europeans is significantly greater than that in female Europeans and the mean in the Indian and African groups is significantly greater than in the male European group

7 There is slight negative correlation between the metacarpo-phalangeal angle and interphalangeal angle in each thumb in the European groups

8 Many subjects in all groups can increase extension at the metacarpo-phalangeal joint after flexing the carpo-metacarpal joint Marked hyperextension (over 40°) is more frequent in the left than in the right thumb, in females than in males, and in male Indians than in male Europeans and Africans

9 Maximum extension at the interphalangeal joints is not related to the presence of a sesamoid bone in the anterior part of the capsule of the joint

10 The surfaces of the metacarpo-phalangeal joints vary considerably in shape Those which are flat form about 10 per cent of the sample and do not show hyperextension

11 The factors influencing the amount of extension at the interphalangeal joint is the degree of laxity of the anterior capsule The problem at the metacarpo-phalangeal joint is more complex, both the capsule and the shape of the joint surfaces play important roles

We wish to thank Mr P Venning for assistance in radiography and Mr F J Pittock for the photographs

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LERI'S PLEONOSTEOSIS, CARPAL TUNNEL COMPRESSION OF THE MEDIAN NERVES AND MORTON'S METATARSALGIA

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There is no account in English literature of the dystrophy described by Leri as pleonosteosis (Gr *pleon*-superabundant), which is characterised by broadening and deformity of the thumbs, flexion contracture of the fingers, thickening and stiffness of the toes, limited movement of other joints, shortness of stature and a Mongoloid facies There are not more than twenty reports in the literature of the world, but it is difficult to believe that the incidence is represented accurately by such paucity of record Four patients with typical contractures of the fingers and toes are described in this note In one there was bilateral compression of the median nerves in the carpal tunnels and bilateral Morton's metatarsalgia with plantar digital neuromata These complications of pleonosteosis have not been described before and they may be significant in the pathology of the disease

REVIEW OF LITERATURE

The family reported by Leri included a man aged thirty-five years and the children of his second wife, a daughter aged four years and a son aged three weeks, who showed a familial and hereditary disorder which was not apparent at birth but became obvious during the first few years of life The child by his first wife was normal

The father measured only 5 feet 2 inches in height His hands were broad and short, with accentuated skin creases between the thickened palmar pads The thumbs were irregularly thickened and there was right-angled flexion deformity of the proximal interphalangeal joints of the fingers Wrist movements were limited to a few degrees The forearms were pronated and the elbows could not be extended fully The arms were held slightly away from the trunk, in some internal rotation, and they could not be raised above the shoulder level In the lower limbs there were similar though less pronounced changes again bilateral and strictly symmetrical, with limitation of movement of the hip joints, fixed external rotation deformity, limitation of extension of the knee joints and slight genu valgum The feet were short and " massive " and the toes broad and stiff

Similar cases have been reported in French surgical literature (Comby 1922, Caussade and Peynet 1924, Crouzon 1924, 1929, Laroche and Barthes 1927, Rothea 1927, Rouillard and Barreau 1927, Rousseau *et al* 1928, Cohen and de Herdt 1928, Apert 1931, Halle and Apert 1931, Feiguine and Tikhodeeff 1932, and Rocher *et al* 1932, 1946, 1947) There are two reports from South America (Valentin 1939, Gareiso *et al* 1946), but no others have been traced The constant feature has been the curious thickening and broadening of the digits especially the thumbs, with flexion contracture of the interphalangeal joints Changes in the proximal joints have varied In some there was limitation of elbow and shoulder movement, or increase in size of the femoral heads with coxa vara, in many there was slight genu valgum, one patient needing two operations for the correction of this deformity, but in others the elbow, shoulder, hip and knee joints were normal Most, but not all, patients showed the Mongoloid facies The influence of heredity was usually obvious, but sporadic cases were reported by Laroche and Barthes, Rocher and Roudil, and Rocher and Pesme

Occasional features may perhaps be ignored, for example, there was evidence in one patient of congenital syphilis (Laroche and Barthes), in one of tuberculosis (Feiguine and Tikhodeeff), in two of corneal opacity (Rocher) and in two of enlargement of the sella turcica (Rocher *et al*) Impairment of intellect was noted only by Cohen and de Herdt, and by Rocher and Roudil In the family reported by Apert there was mental deficiency, but the diagnosis of pleonosteosis may be in doubt because although there was contracture of the fingers, the three patients suffered from delayed speech and from progressive deafness and cachexia and they all died in childhood

Leri was impressed by the bone changes, particularly the large epiphyses and thick metaphyses of the phalanges and metacarpals He thought that excessive epiphysial development was the characteristic feature and that this accounted for the postural abnormality and limitation of joint movement He was supported by Rocher and Roudil in their report of an infant who was observed for three years from the age of twenty-six days—the youngest recorded patient The centres of ossification in the femur, tibia and tarsus corresponded at birth to those of an infant aged six to twelve months, but the centres of ossification for the metacarpal bones were unusually delayed In other reported cases all centres of ossification appeared at the normal date (Halle and Apert)

The short, broad, thick hands and feet, the limited extension of knees and elbows, and the fixed internal rotation of the upper limbs and external rotation of the lower limbs, suggested to Leri an atavistic return to the simian attitude He pointed out that it was only in the third or fourth month of intra-uterine life that the limbs began to rotate so that the patella would be in front of the knee joint and the olecranon behind the elbow joint Leri wrote "the characteristics of pleonosteosis approach closely those of the Mongolian race—the mother of all human races—and they are indeed a reversion to an atavistic race" But the Mongols show no skeletal abnormality, not all patients with pleonosteosis have a Mongoloid facies, and many patients with advanced contracture of the fingers and toes have no deformity of the limbs and no resemblance at all to the simian attitude Was Leri right?

CASE REPORTS

Case 1 P L, female, aged 21 years, farm worker—Flexion deformity of the fingers of both hands was noticed in early life and increased steadily (Fig 1) At the time of examination in cold weather there was a tendency to cyanosis of the hands and it was thought that there might be slight wasting of the thenar and first dorsal interosseous muscles Radiographs showed buttress enlargement of the seventh cervical transverse processes and the disability was attributed to the costo clavicular syndrome

Fig 1

Case 1 Flexion contracture of the proximal interphalangeal joints Despite the normal facies the diagnosis of pleonosteosis was established by broadening of the thumbs similar deformities of the toes significant changes in the proximal joints, and comparable deformities in the mother aunt, great-aunt and great-grandmother

Four years later it was reported that the deformities had increased and provisional arrangements were made for exploration of the supraclavicular triangles of the neck Further examination then disclosed features that should no doubt have been observed long before There was not only flexion contraction of the proximal interphalangeal joints but also broadening of the thumbs The toes showed similar flexion

contractures In the shoulders and hips there was slight limitation of rotation Examination of the patient's mother (Case 2, Mrs L, aged 53 years) disclosed that she too had broad thumbs and flexion deformity of the fingers and toes though of less degree The patient's aunt (Case 3 Miss G I aged 51 years) had flexion deformity of the interphalangeal joints of both hands and "hammer toes Two of the patient's great-aunts and her great-grandmother had been proud of "the Bridge hand this referred to the family name and not to the game, they all had flexion deformity of the interphalangeal joints

Comment—The youngest member of this family narrowly escaped exploration of the neck for excision of "the fibrous remnants of cervical ribs" but there can be little doubt that she and her maternal relatives showed, in attenuated form, the contractures and deformities characteristic of pleonosteosis It is true that changes in the proximal joints were minimal and that, far from the facies being Mongoloid, the patient was very attractive, but we know from the literature that these features are not essential to the syndrome of pleonosteosis

Case 4 J D H, male, aged 20 years, forester—*Family history*—Parents and grandparents normal Only sister normal No brothers

History—He was apparently normal at birth In childhood his schoolmates laughed because he could not point with a straight finger and this deformity is shown in early photographs He learned to write with a pencil held between the index and middle fingers and in due course he graduated at a University The deformities of fingers and thumb increased steadily

FIG 2

FIG 3

Case 4 The facies are Mongoloid with a broad flat nose and typical curve at the inner canthus (Fig 2) The toes are broad and contracted like the fingers (Fig 3)

In recent years he had noticed numbness tingling and pins and-needles in the index and middle fingers of both hands He could seldom sleep for more than six hours After a strenuous day of harvesting or after rowing, he would wake in the early morning with intense pain in the fingers and hands If he had been particularly energetic the pain spread up the forearms almost to the elbows

Three years ago he noticed pain in the left *fourth* toe when wearing shoes If he kept the shoe on the pain spread but if he took it off the pain disappeared and he could then put it back and keep going for half an hour Tingling and numbness were felt in the toe, and pressure under the fourth metatarsal head caused "clicking" The symptoms were worse in warm weather There were no symptoms in the right foot

Clinical examination—An intelligent powerfully built man of short stature (5 feet 4 inches) Face broad and square bridge of nose wide and flattened eyes set apart with Mongolian curving of the upper eyelid at the inner canthus (Fig 2) Hands short and square Thumbs broad and thick with valgus deformity of the interphalangeal joints and slight varus deformity of the metacarpo-phalangeal joints (Figs 4 and 5) Thenar eminences thickened with accentuation of the palmar creases (Fig 7) *Fingers*—flexion contracture of all joints 90 degrees at the distal joints 40 degrees at the proximal interphalangeal joints, 30 degrees at the metacarpo-phalangeal joints the deformity remained the same no matter what the position of the wrists showing that the contractures were due to capsular and not tendon shortening Radiographs showed thickening of the shafts of the metacarpals and phalanges but no significant bone deformity of the joints (Fig 6) *Wrist joints*—thickening of periarticular tissues dorsiflexion limited to 20 degrees, palmar-flexion to 30 degrees Radiographs showed obliquity of the lower radial articular surface

Fig 4

Fig 5

Fig 6

Fig 7

Case 4 Typical case of pleonosteosis Photographs of the left hand in full flexion (Fig 4) and full extension (Fig 5) demonstrate the limited movement contracture of interphalangeal joints and deformity of the thumb The radiograph shows thickening of the metacarpals and phalanges but not sufficient bone change to cause joint contracture (Fig 6) The accentuated palmar skin creases and the limitation of supination of the forearms are shown in Figure 7

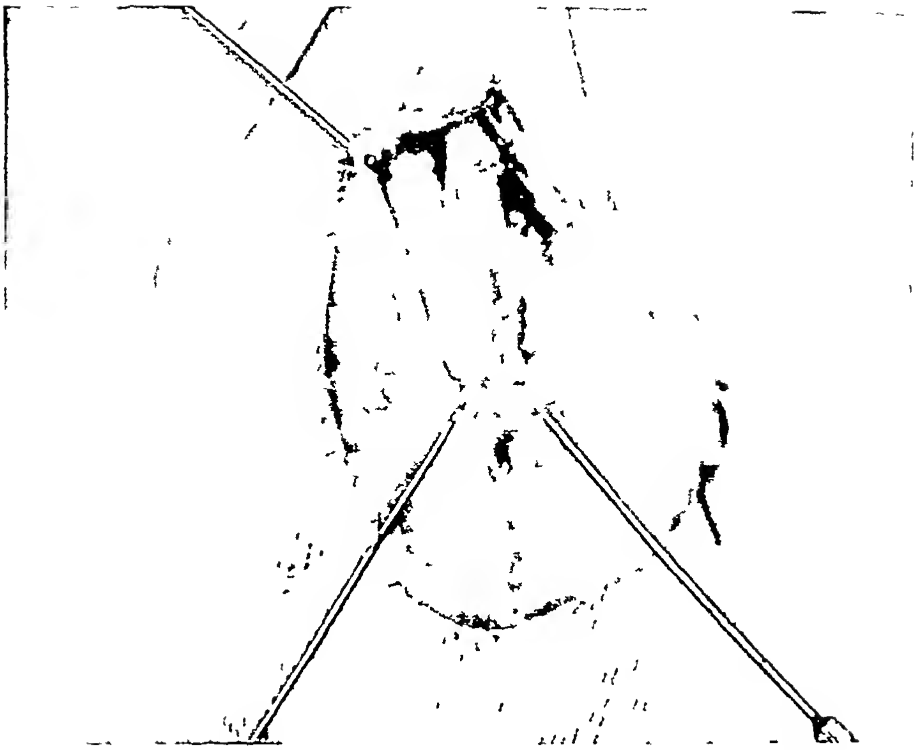

FIG 8

Case 4 Exposure of the median nerve at the wrist joint (right) The upper hook is retracting palmaris longus The lower hooks are at the proximal margin of the anterior carpal ligament The median nerve is expanded to a neuroma 11 millimetres in diameter The normal nerve above measures 7 millimetres

FIG 9

Case 4 The anterior carpal ligament has been excised together with part of palmaris longus (specimen on left) it was three times its normal thickness Beneath it the median nerve was discoloured and attenuated, measuring only 3 millimetres The operative findings in the left wrist were identical

slight relative shortening of the ulna but no thickening of the joint margins, no osteophytes and no abnormality of the carpal bones *Median nerves*—In both hands there was loss of touch and alteration in the quality of pain over most of the digital part of the median supply No wasting or paresis of the intrinsic muscles Sensation in the ulnar distribution normal *Other joints of the upper limbs*—Pronation of the forearms limited to 30 degrees and supination to 40 degrees Movement of the elbow joints normal Shoulder joints normal except for slight limitation of external rotation Clavicles skull, spine and pelvis normal *The lower limbs—Internal rotation of the hip joints 20 degrees, external rotation* 40 degrees other movements normal Radiographs showed wide femoral necks Knee and ankle joints normal *Feet*—short and broad, 9 5 inches long 4 inches wide, the shoes were two sizes larger than needed for the length of the foot Great toes short and thick like the thumbs, slight valgus deformity at the terminal joints Flexion contracture of all toes, to the right-angle at the terminal interphalangeal joints (Fig 3) Transverse arches flattened *Plantar digital nerves*—Tenderness on pressure over the bifurcation of the digital nerve to the cleft between third and fourth toes No neuroma felt No objective change in sensation *General condition*—He was seen by Sir Henry Cohen who excluded abnormality of the central nervous system, found no metabolic change on detailed blood examination, and established the diagnosis of Léri's pleonosteosis

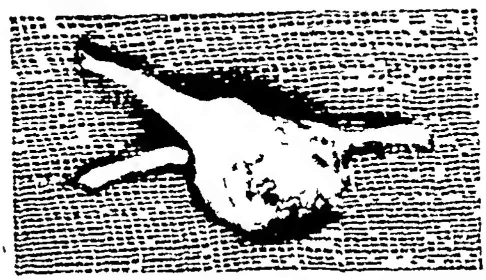

FIG 11

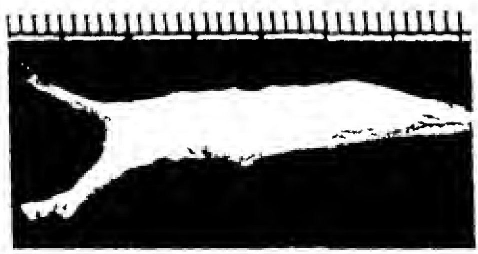

FIG 10 FIG 12

Case 4 Plantar digital neuroma at the third-fourth cleft In the right foot (Figs 10-11) there was an eccentric neuroma with thickening of the branch to the fourth toe—to which pain was referred The neuroma from the left foot was more diffuse (Fig 12—scale in millimetres)

First operation, *September* 1947—*Resection of both anterior carpal ligaments with neurolysis of median nerves excision of plantar digital neuroma* (*left*)—The median nerves were exposed (right Mr Raymond King, left R W-J) Immediately above each carpal tunnel the nerve was expanded over a distance of 2 centimetres to form a neuroma 11 millimetres in diameter the normal nerve above measured 7 millimetres (Fig 8) The anterior carpal ligament was resected It was much tougher and three times thicker than normal Deep to the ligament the nerve was obviously compressed and attenuated measuring only 3 millimetres in diameter, it had lost its normal sheen and appeared discoloured (Fig 9) Immediately distal to the ligament the nerve regained its normal appearance and again measured 7 millimetres

Through a plantar incision the digital nerve to the third-fourth cleft was exposed Just proximal to its bifurcation and lying over the transverse ligament, was a neuroma three times the normal diameter of the nerve and almost 3 centimetres long (Fig 12) The nerve and neuroma were excised The plantar digital vessels were not recognised

Second operation, *September* 1948—*Excision of plantar digital neuroma* (*right*)—During the previous year the patient complained increasingly of symptoms in the right foot exactly similar to those in the left The first attack occurred while wearing hobnail boots, and two others coincided with the first wearing of new shoes The digital nerve to the third-fourth cleft was exposed and a neuroma was removed (Figs 10 and 11) It was similar to the one removed previously except that it was eccentric and involved a

shorter length of nerve It showed a fibrous swelling extending from the digital nerve itself into the branch to the fourth toe but not to that for the third toe This finding corresponded with the reference of pain to the fourth but not to the third toe

Progress—Pain in the hands was relieved within a few days of the first operation but impairment of sensation persisted for twelve months before recovery was complete In each foot relief of pain was gained promptly after operation Now after two years although the deformities of the hands and feet are the same he does full work as a forester and often walks fifteen miles a day over peat-bogs and sand-dunes

Pathological report (Professor Dorothy Russell Bernhard Baron Institute of Pathology, London Hospital)

1) *Anterior carpal ligament*—The specimen consists of a strip of the palmaris longus tendon to which is attached a mass 3 8 centimetres long and 1 2 centimetres thick, of tough, grey tissue corresponding to the anterior carpal ligament Macroscopically it is abnormally thick *A control specimen* measures up to 0 4 centimetres thick this normal anterior carpal ligament is composed of closely woven bundles of rather acellular collagenous tissue containing scanty elastic fibres which collectively form a layer up to 0 1 centimetres thick bordering the smooth inner surface of the carpal tunnel Superficial to this surface the collagen bundles ramify through a zone of adipose tissue which includes vessels of supply and small bundles of nerve fibres and this layer is also intersected by bundles of stout elastic and finer collagen fibres (Fig 13) *The pathological specimen*—The collagenous tissue is greatly increased forming almost the whole of the section A large proportion is actually fibrocartilage, in association with which a good deal of mucinous material is laid down both in relation to the cells and in linear deposits between the collagen fibres There is a remarkable absence of elastic tissue in comparison with the control (Figs 14 and 15) A small amount of skeletal muscle is attached to the surface this shows advanced atrophy of the fibres and associated fibrosis The tendon appears normal There is no demonstrable vascular abnormality Two twigs of nerve at the periphery of the specimen show early mucinous change and fibrous increase of the endoneurium

2) *Plantar digital neuroma*—The excised portion of digital nerve forms a fusiform mass 3 7 centimetres long and up to 0 5 centimetres thick A longitudinal section shows wide separation of the constituent nerve bundles by collagenous tissue of variable density containing evenly distributed spindle fibroblasts and small vessels mainly arterioles and venules There is no inflammatory cellular infiltration apart from one small group of perivascular lymphocytes Tissue mast-cells are scattered throughout the collagenous tissue Several of the nerve bundles appear greatly swollen from the presence of mucin especially in the endoneurium, and from uneven fibrous thickening of this tissue and of the perineural sheaths A few tissue mast-cells are present In the more swollen bundles the axis-cylinders, demonstrated by Bielschowsky's method are parallel but widely separated The presence of occasional amoeboid macrophages suggests that some have undergone degeneration and have disappeared but stages of the process are not demonstrable None of the blood vessels in this preparation shows degeneration or occlusive change

3) *Summary*—The digital neuroma is of the ischaemic type such as may occur in cases of Volkmann contracture but the specimen does not provide evidence of the cause of the ischaemia The anterior carpal ligament is greatly thickened by fibrocartilaginous alteration of the collagen This may reasonably have produced compression and atrophy of adjacent structures If a similar change is widely spread in other ligaments the digital neuroma might be attributable to this

DISCUSSION

Pathology of pleonosteosis—Leri believed that the pathological basis of this disorder was premature and excessive ossification with epiphysial enlargement accounting for deformity The title he chose leaves no doubt as to his view but it is an unfortunate title Despite the support of Rocher and Roudil, there has been no general evidence of "precocity of ossification" Moreover, the contracture of joints has always been far greater than would be expected from the relatively limited bone change This was evident in all four patients in this series, even in Case 4, the thickening of the metacarpals and phalanges was not associated with bone change at the joints sufficient to account for right-angled flexion deformity

There have been no previous studies of the ligaments and capsules in pleonosteosis The evidence now available shows that, in at least one case, there was striking change in the carpal ligaments which were short, thick, lacking in elastic fibres, and largely changed to fibrocartilage When this is correlated with the clinical observation that the deformities were due mainly to capsular contraction, it seems possible that the primary pathological change in pleonosteosis may be in the joint ligaments, and that the bone thickening may be due to periosteal traction at their metaphysial attachments

FIG 13

Whole thickness of the anterior carpal ligament in a normal wrist serving as control (haematoxylin and van Gieson × 27)

FIG 14

Whole thickness of the anterior carpal ligament in Case 4 (pleonosteosis with carpal tunnel compression of median nerve) The preparation has the same magnification and is stained in the same way as in the control specimen in Figure 13 (haematoxylin and van Gieson, ×27) There is great increase in the collagenous tissue much of it is actually fibrocartilage which is seen in higher magnification in Figure 15 (haematoxylin and eosin × 150)

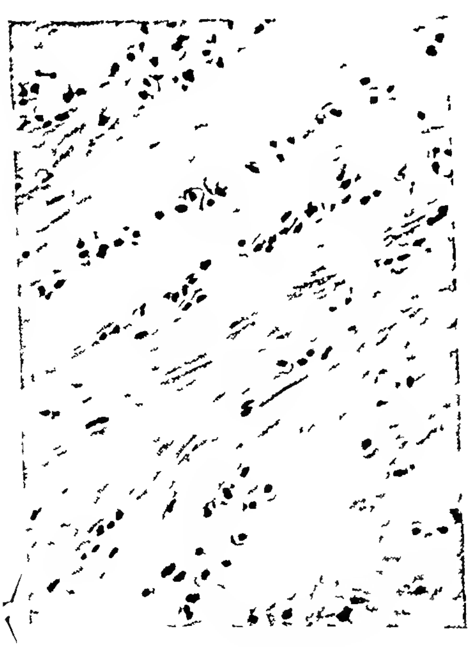

FIG 15

Leri and other writers were at pains to distinguish pleonosteosis from achondroplasia which of course it does not resemble A closer analogy could be drawn with arthrogryposis multiplex congenita, in which there are congenital and hereditary tendencies, sometimes a Mongoloid facies, and more severe joint contractures due solely to changes in the soft tissues (Middleton 1934) But we have only begun to study the pathology of this disease and many further investigations are needed

Carpal tunnel compression of the median nerve—Injury to the median nerve at the wrist by the pressure of a dislocated bone or displaced fracture has long been recognised and "tardy median palsy" occurring many years after fracture has been described Recently there have been reports of compression of the nerve in a carpal tunnel that was normal, or at least, not encroached upon by bone thickening There are two records of nerve compression at this level in patients with acromegaly These nerve lesions have often been grouped together, but it would be wise to differentiate them

Acute compression by bone—The fact that median paralysis seldom complicates recent fractures of the lower end of the radius even when widely displaced, but that it often occurs when the semilunar bone is dislocated forwards, indicates the susceptibility of the nerve to compression within the confined space beneath the anterior carpal ligament

Acute compression by haemorrhage—In 1943 this writer mentioned the case of a doctor who stopped a fast cricket ball in the palm of his hand After two hours he felt tingling and then intense pain in the distribution of the median nerve The lightest touch on the fingers precipitated agonising waves of pain Aspiration of sixteen cubic centimetres of blood from the palm gave temporary relief but it was not until the anterior carpal ligament had been divided that the agony was relieved The ligament itself was normal and there was no bone injury The median paralysis, which recovered after several months, was due to acute compression in the tunnel by haemorrhage

Slow compression by bone—There are many accounts of late median palsy due to compression of the nerve by displaced bone fragments, or by the osteophytes of hypertrophic arthritis from old carpal injuries In two patients reported by Zachary (1945) the injury had been fracture of the carpal scaphoid bone, the median paralysis recovered after section of the anterior carpal ligament by Seddon Cannon and Love (1946) described eight patients with median neuritis due to deformities of the carpal bones from fractures sustained twenty to fifty years before In one of the three cases reported by Newman (1948) a fracture of the scaphoid bone was complicated by median paralysis after an interval of twenty years In these and other records the neuritis has been of ischaemic origin, due to compression of the nerve by bone thickening in the floor of the tunnel, and relieved by division of the anterior carpal ligament with decompression of the nerve Other accounts of tardy median palsy include cases that were not true examples of carpal tunnel compression, the fracture being in the lower end of the radius (Paget 1863, Lewis and Miller 1922, Abbott and Saunders 1933)

Slow compression by occupational strain—Moersch (1938) reported one patient with no bone deformity whose median nerve paralysis was relieved by section of the ligament Cannon and Love (1946), in their series of thirty-eight cases included three with median palsy of spontaneous origin without radiographic evidence of bone abnormality Brain, Wright and Wilkinson (1947) described six women with bilateral median neuritis all in the second half of life, and in all of whom the wrist bones were normal Operative exposure showed a neuroma of the median nerve immediately proximal to the anterior carpal ligament with flattening of the nerve beneath it Similar cases have been reported by Newman (1948) and others Brain and Wright believed that the carpal tunnel was normal and that the palsy was due to occupational stress They showed that, in a cadaver, pressure in the tunnel was three times greater when the wrist was *fully extended* than

when it was flexed, and pointed out that many household occupations were performed with an extended wrist They surmised that postural strain alone caused pressure on the nerve, degeneration in the artery to the nerve, and oedema of the nerve which increased the pressure still more

The influence of occupation is undoubted The neuritis may occur in any worker "whose business entails grasping instruments for long periods or pressing them into the ball of the thumb" (Kinnear Wilson 1940) But it is unfortunate that in none of these contributions was there a pathological study of the anterior carpal ligament Is it right to assume that simple postural strain may cause paralysis of a normal median nerve lying in a normal carpal tunnel? It would seem more likely that occupational stress and advancing age cause thickening of the anterior carpal ligament and that this is the source of compression of the nerve The possibility gains support from Case 4 in this series

Slow compression by thickening of the anterior carpal ligament—Case 4 shows clear evidence of compression of the median nerve by an abnormally thick carpal ligament Two other reports may be significant Woltman (1941) described an acromegalic patient with median paralysis which recovered after division of the anterior annular ligament Cannon and Love (1946) reported another patient with acromegaly who gained relief from pain and paraesthesia in the median distribution of the hand by division of the ligament Woltman said that the nerve was compressed in front of the wrist joint "by proliferation of tissues" *

It may be, of course, that carpal tunnel compression of the nerve by ligamentous thickening is peculiar to certain constitutional diseases But before accepting the suggestion of Brain, Wright and others that simple postural strain is an additional cause of compression of the median nerve at the wrist, detailed pathological studies of the ligament whenever it is removed for tardy median palsy should be reported

Plantar digital neuroma and metatarsalgia—In many patients, pain under the tread of the foot arising from walking or long standing, usually referred to the fourth toe but sometimes to the third or even second toes, often associated with numbness and tingling, and nearly always relieved by removing the shoe, is still being attributed to "anterior flat foot" and treated unsuccessfully by metatarsal pads and exercises Betts (1940) demonstrated that there was fibrous swelling of the digital nerve and that the symptoms were relieved by resecting the neuroma In a recent study, Nissen (1948) in collaboration with Holmes, showed that the nerve lesion is ischaemic in nature and that severe degenerative changes in the digital artery precede the marked increase of connective tissue that provides the main bulk of the nerve expansion

The typical neuromata removed from the digital nerves to the third-fourth cleft in each foot of Case 4 may have been coincidental, or due to no more than that the contracted toes were associated with flattening of the transverse arches with consequent weight-bearing injury to the digital arteries and nerves But there is evidence to show that the digital neuritis of metatarsalgia is not related to transverse flat foot or to weight-bearing injury The primary lesion is certainly in the digital artery Nissen (1948) indicated the importance of the narrow fibrous tunnel at the proximal margin of the transverse metatarsal ligament through which the digital artery must pass to enter the cleft It is not yet known why the digital artery to the third-fourth cleft should so often show the degenerative change, or why a similar lesion should arise less commonly in other clefts But Nissen's observations indicate that the vascular supply to the plantar digital nerves should be studied in more detail In Case 4 it seems possible that the ischaemic nerve lesions in the feet were due to compression of the digital arteries by abnormal plantar ligaments, comparable to the proved compression of the median nerves by abnormal carpal ligaments

* In acromegaly there may also be plantar digital neuritis with neuroma formation (Nissen—personal communication)

SUMMARY

1 Leri's pleonosteosis is characterised by broadening and deformity of the thumbs and great toes, flexion contracture of the interphalangeal joints, limited movement of other joints, and often a Mongoloid facies Four such cases are described

2 A review of the twenty reports in the literature, and the cases now described, shows that the deformities are due to capsular contracture rather than deformity of bone

3 In one patient there was striking evidence of fibro-cartilaginous thickening of the anterior carpal ligaments It is suggested that the primary pathological change in pleonosteosis may be in the joint capsules rather than in the epiphyses

4 The patient with thickening of the anterior carpal ligaments had bilateral median palsy from carpal tunnel compression

5 The causes of carpal tunnel compression of the median nerve are reviewed Acute compression may be due not only to dislocation of the semilunar bone but to haemorrhage in the palm Late compression by bone may occur twenty to fifty years after injury Late compression without bone abnormality has been attributed to occupational stress but it is suggested that pathological thickening of the anterior carpal ligament may be the cause

6 The patient with pleonosteosis and bilateral median palsy had also bilateral Morton's metatarsalgia with large digital neuromata

7 Plantar digital neuritis has already been shown to be an ischaemic nerve lesion preceded by degenerative changes in the digital artery The significance of the fibrous tunnel through which the artery passes to reach the digital cleft is considered

I am grateful to Professor Dorothy Russell for her co-operation to Sir Henry Cohen whose aid in Case 4 was invaluable to Mr Raymond King and my other colleagues at the London Hospital, and to Mr Ruddick clinical photographer and Mr John King who prepared the micro-photographs

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EXCISION OF THE CARPAL SCAPHOID FOR UNUNITED FRACTURE

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During the last twenty years great progress has been made in the diagnosis and treatment of fractures of the carpal scaphoid. Formerly non-union was the accepted end result (Jones and Lovett 1923), but union by bone is now obtained in a high proportion of recent fractures. Nevertheless, non-union is still common. Most cases are discovered by chance or because the patient has a second injury. Certainly many patients with non-union have performed strenuous work for many years with nothing more than vague discomfort, and the accidental discovery of non-union does not demand special treatment. It must, however, be regarded as a potential source of trouble for two reasons: first, because of the almost inevitable development of osteoarthritic changes, and second, and far more important, because of the disastrous effects that often follow a further injury, particularly if arthritic changes are already present. The aggravated traumatic arthritis is seldom relieved by conservative treatment and the capacity of the patient for work may be greatly and permanently diminished.

Several observers have reported the results of total excision of the scaphoid (Bohler 1929, Aleman 1937–38, Soto-Hall 1948), but the relatively small numbers of cases left no margin to allow for the possibility of unfortunate selection. Hirsch (1935) reported favourably on nine patients, and Davidson and Horwitz (1938) were equally satisfied with the results of eight. All these observers believed that the operation should be done before the development of arthritis, but it must be remembered that arthritic changes are often present when the non-union is first recognised. We consider that total excision of the ununited scaphoid is of considerable value in selected cases.

TREATMENT OF NON-UNION BY TOTAL EXCISION OF THE SCAPHOID

This paper reports the end-results in nineteen patients who were treated by total excision of the bone. With two exceptions the disabling symptoms had been caused by a second injury. In all of them rest and physiotherapy had been tried without success. Of the nineteen patients, seventeen have been examined recently by the writer and two have replied to detailed questionnaires. One woman who was operated on by another surgeon thirteen years ago is included because the operation was performed only six months after the initial injury; in the other eighteen, all personal cases, eighteen months was the shortest intervening period. Seventeen patients were men and two were women. The average age at the time of operation was thirty-two years, the youngest being nineteen and the oldest fifty-one years. Excision was performed thirteen years ago in one patient, five to seven years ago in ten patients, and one to five years ago in eight patients.

Technique of the operation—A straight incision is made over the anatomical snuff box. The radial vessels and branches of the radial nerve are retracted and the capsular tissues are dissected off the dorsal aspect of the scaphoid. The bone is excised after careful division of the interosseous ligaments by a tenotomy knife and without any unnecessary use of elevators. The structures attached to the tuberosity are best dissected off at an early stage, and a preliminary incision over the palmar aspect of the wrist may be used for this purpose. Forcible removal of the bone, causing damage to adjacent articular surfaces and stretching of ligaments, may be responsible for some of the disappointing results that have occurred after this operation.

Excision of the radial styloid process—The *tip* of the styloid process was excised in seven patients and this should be done in every instance where there is marked arthritic "pointing"

* *Paper read at the Bristol meeting of the British Orthopaedic Association, October 1949*

This opinion is supported by the findings of Barnard and Stubbins (1948). It was noted, however, that the end of the styloid process gradually becomes rounded of its own accord after excision of the scaphoid (Figs. 1 and 2). The wide excision of the radial styloid advocated by Barnard and Stubbins is contra-indicated when the scaphoid bone is also being excised because instability of the wrist joint may result.

FIG. 1

FIG. 2

A patient aged fifty years complained of severe pain after a recent injury to the wrist. Figure 1 shows the old ununited fracture of the scaphoid, pointing of the radial styloid process and general arthritis. The lateral view showed forward sliding of the semilunar. Figure 2 is the radiograph five years after complete excision of the scaphoid. The radial styloid process, which was not excised in this case, has rounded off. There is no radial deviation of the wrist. Full movements were regained.

FIG. 3

FIG. 4

Patient aged twenty-seven years. The proximal pole of the scaphoid bone had been removed eighteen months previously. There was persistent pain and disability. Figure 4 shows the same case six years after excision of the distal fragment of the bone. No arthritis has developed. Movements are full and the patient is doing strenuous work.

After-treatment—The wrist joint is immobilised on a short cock-up splint until all signs of irritation have subsided, usually after four to seven weeks. There is certainly nothing to be gained from encouraging movement too early. When movements are begun, progress is rapid, and most patients return to light work within two to four months.

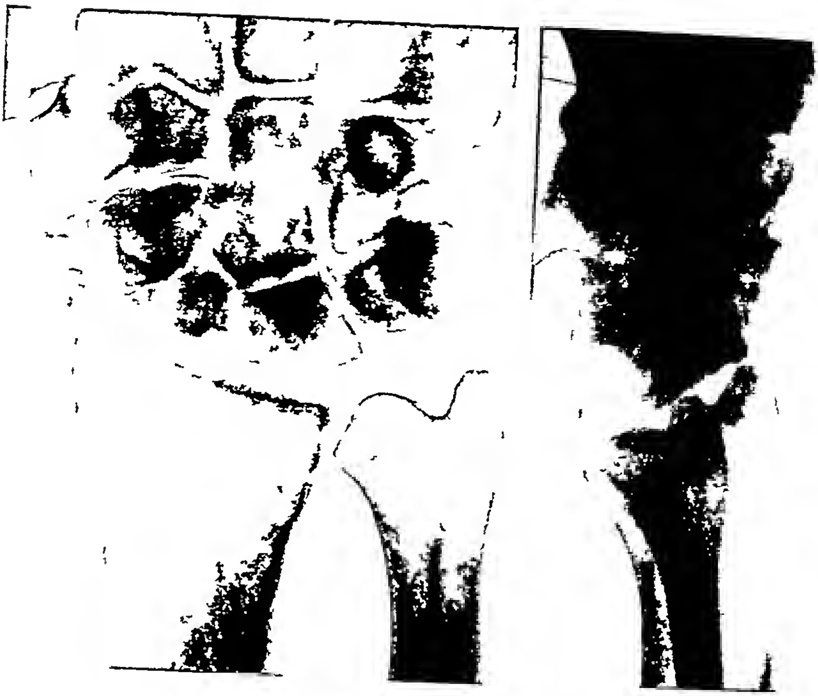

FIG 7

FIG 8

Figure 7 shows the radiographs of a patient, aged forty-two years with an ununited fracture of the scaphoid Note the arthritic changes on the dorsal and radial aspects of the joint and also the posterior subluxation of the head of the os magnum Figure 8 shows the radiograph four years after complete excision of the scaphoid This gave a "bad" result The patient is doing light work in a coal mine

scaphoid had been excised but pain and disability persisted until the remaining part of t bone was excised two years later (Figs 3 and 4), since then he has worked as a milk round-r with nothing more than aching in cold weather and some weakness In another case a b graft had been performed eighteen months before the excision Of the three patients cla

as "very good," one was the woman already mentioned who had been operated on thirteen years ago, and two were engaged in very heavy occupations five and six years after operation

Late results and late displacement of the semilunar—No deterioration of the wrist joints appears to have taken place in any patient after operation In three, the condition was much improved by manipulation Late radiographs show that in some cases there had been progressive forward displacement of the semilunar bone (Figs 5 and 6), but this displacement was also present in several patients before operation and its significance is not quite clear As the semilunar slides forward, the head of the os magnum and the posterior margin of the radius come into close contact and this may possibly lead to local arthritic changes

Movements of the wrist joint after excision of the scaphoid—All patients suffered from some degree of stiffness before operation, in none were movements affected adversely but in the four patients with bad results there was no improvement Four patients regained practically full movement and in the remaining eleven the range was improved Maximal recovery sometimes took a year or more Radial deviation of the hand was not seen and radiographs taken after several years show the wide gap still present at the site of excision (Figs 2, 4)

CONCLUSIONS

1 The late results in nineteen cases of total excision of the carpal scaphoid bone for ununited fracture have been reviewed

2 The results are least satisfactory when there is clinical evidence of arthritis on the dorsal aspect of the wrist, or subluxation of the os magnum and semilunar In other cases good results usually can be expected

3 The operation must be done carefully without injury to the neighbouring bones and ligaments Total excision is preferable to excision of the proximal pole alone

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PRONATION INJURIES OF THE FOREARM

with Special Reference to the Anterior Monteggia Fracture

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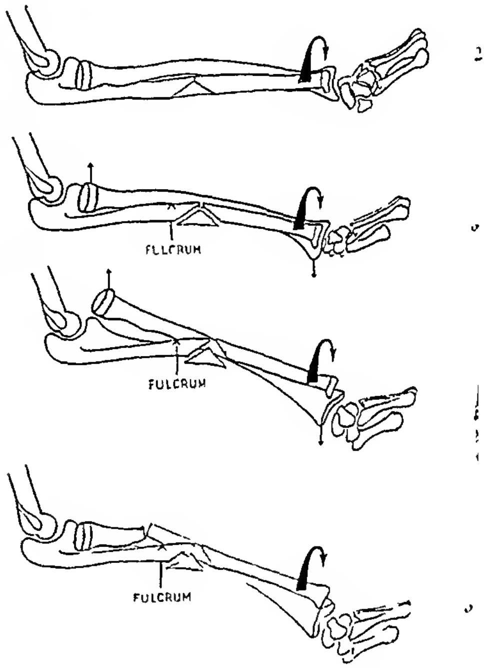
The exact mechanism of an injury is often difficult to determine A patient with a severe fracture of the forearm is seldom able to give precise details of his accident, and mechanism of many such fractures is thus still unknown Why, for instance, should one ch sustain a greenstick fracture of the lower ends of the radius and ulna, another a separation of the epiphysis of the head of the radius, and yet another a supracondylar fracture of the humerus, all from apparently similar falls on the outstretched hand? The answer surely must be that a number of other factors are involved, such as the position of the elbow at the time of impact, the direction in which the body is falling, and so on

Fig 1

With a fall forward on to the hand the forearm is pronated and the hand is palm downwards If the body is twisting outwards at the moment of impact, a strong pronation force is transmitted through the humerus to the forearm



Figs 2–5

Diagrams illustrating the mechanism of pronation injuries of the forearm The bones of the right forearm are seen from the lateral aspect In pronation the radius and ulna cross near the junction of their upper and middle thirds (Fig 2) The ulna may be fractured either by the rotation force shown here or by angulatory strain At the same time the upper third of the ulna acts as a fulcrum over which the upper end of the radius is forced forwards if the pronation force continues (Fig 3) The result is either dislocation of the head of the radius (Fig 4) or a transverse fracture near its upper end (Fig 5)

When a patient falls forward on to the outstretched hand the forearm is already prona and at the moment of impact the hand becomes relatively fixed to the ground To th downward momentum of the falling body a rotation force is added when twisting o trunk causes external rotation of the humerus and ulna (Fig 1) If this force conti until the normal range of pronation at the radio-ulnar joints is expended, something give The ulna cannot rotate, because it is fixed below by the ulnar carpal ligament above by its articulation with the humerus The ulna is therefore liable to fracture, and combination of the rotation force and of the bending force set up by longitudinal compre

may produce an oblique, transverse or butterfly fracture in accordance with the principles set out by Messerer (Figs 2 to 5) At the same time the radius is forced into extreme pronation and lies across the ulna, at the junction of the upper and middle thirds As the ulna fractures, the two bones come into contact, and the point of contact forms a fulcrum over which the upper end of the radius is forced forward As the pronation force continues, the radius is either levered forward out of the superior radio-ulnar joint or is fractured in its upper third

On theoretical grounds, then, one would expect forced pronation to cause one of three injuries, all of which are well-known 1) fracture of the ulna in its middle third with backward angulation and anterior dislocation of the head of the radius—the anterior Monteggia fracture, occasionally the head or epiphysis of the radius is damaged at the same time, 2) fracture of the ulna as above with a high fracture of the shaft of the radius, 3) anterior dislocation of the head of the radius without fracture of the ulna

THE ANTERIOR MONTEGGIA FRACTURE

Although forced pronation may cause any of the injuries mentioned, and probably others (Fitzgerald 1947), this paper is concerned mainly with the anterior Monteggia fracture, the treatment of which has long been considered difficult (Fig 6) Watson-Jones (1943) stated that it caused permanent disability in 95 per cent of adults in a series of cases treated by many surgeons and gave a formidable list of complications He advised open reduction and plating of the ulna with post-operative fixation in a plaster spica

Closed reduction and immobilisation in supination have been mentioned in the literature by several authors Speed and Boyd (1940) advocated plating of the ulna with repair of the superior radio-ulnar dislocation by a fascial sling, but they stated that in children and sometimes in adults the injury might be reduced by manipulation In such cases they advise supination "to relax the biceps and supinator muscles and so diminish the upward pull of the biceps on the radial head and the radial pull on the ulna by the supinator" Wise (1941) reported a case of lateral dislocation of the head of the radius with fracture of the ulna treated by open reduction and noted that the dislocation was reduced by traction and supination Consistently good results by closed methods have been reported only by Naylor (1942) who advocated traction and pronation with the elbow flexed 90 degrees and, if this failed, traction in flexion and supination Nevertheless the primary importance of supination has not been emphasized up to the present

FIG 6
An old case of Monteggia fracture illustrating non-union of the ulna and anterior dislocation of the head of the radius with a plaque of calcification

Mechanism—Most authorities consider the injury is due to a direct blow on the back of the forearm which fractures the ulna at the point of impact and forces the head of the radius forward While it is possible that this may sometimes occur, there are several reasons for believing it to be exceptional

1) At the site of fracture the ulna is subcutaneous and, if the fracture were due to direct violence, one would expect to find severe bruising or breaking of the skin at the point of impact In no case in the present series was this so, one case was indeed compound, but the ulna had penetrated the skin anteriorly well away from the supposed point of impact In support of his belief that the injury is due to direct violence, Naylor stated that there was considerable bruising at the site of the ulnar fracture which in a large proportion of cases was said to be compound Nevertheless in the only case of compound fracture reported in detail in

his review the wound was also on the anterior aspect of the forearm Figure 7 is a photograph of a patient taken on admission, the skin over the ulna is unmarked

2) If the fracture of the ulna were due to direct violence one would expect more comminution than is usually seen In the Monteggia fractures reported here the pattern of the fracture was that which one would expect from either a rotation strain or from a longitudinal compression force, in no case was the fracture comminuted

3) When patients have given a clear history of a blow on the back of the forearm, the injury sustained has been either a fracture of the shaft of the ulna or fractures of the shaft of both bones at roughly the same level, but in no case a forward dislocation of the head of the radius

4) Finally, dissected specimens show clearly that the capsule of the superior radio-ulnar joint is strong anteriorly and is protected by the supinator brevis and brachialis muscles It seems unlikely that a direct blow would be sufficient to cause dislocation, especially if some of the force were spent in fracturing the ulna, a twisting force, increased by leverage action as the radius crosses the ulna in pronation, would be much more likely to do so

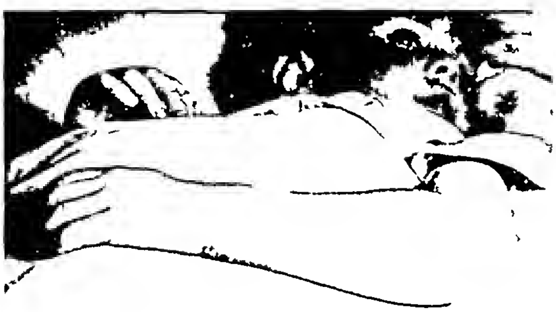


FIG 7

A child with a Monteggia fracture photographed soon after admission to hospital Note the prominence caused by the displaced radial head The skin over the ulnar fracture is unmarked

FIG 8

The radiograph of an anterior Monteggia type of fracture in a child, showing backward tilting of the head of the radius with the forearm in neutral rotation

Confirmatory evidence of the mechanism of the Monteggia fracture is shown in the case illustrated in Figure 8 The lateral view of the forearm in neutral rotation shows tilting of the epiphysis of the head of the radius in addition to anterior dislocation It is well known that such epiphysial displacements are caused by the head of the radius striking the capitellum while a valgus strain is being thrown on the joint, and that the epiphysis always tilts *laterally* Here in neutral rotation the epiphysis is tilted backward, indicating that the radius has been externally rotated through 90 degrees from the position of full pronation at the moment of injury

TABLE I

RESULTS OF PRONATION STRAIN ON THE FOREARM IN EIGHTEEN SPECIMENS

12 cases	Fracture of the ulna in its middle third and anterior dislocation of the head of the radius (the anterior Monteggia fracture)
3 cases	Fracture of the ulna in its middle third and transverse fracture of the radius just below the tuberosity
2 cases	Anterior dislocation of the head of the radius without fracture of the ulna
1 case	Dislocation of the elbow

FIG 9

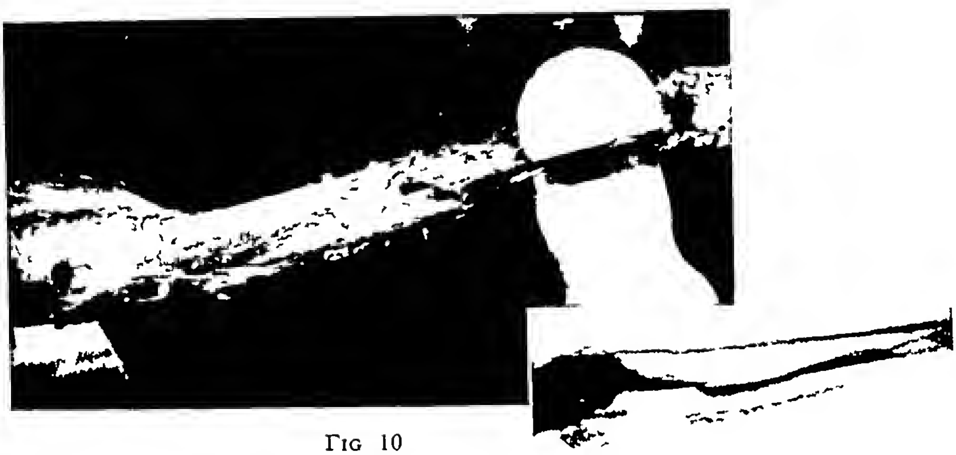


FIG 10

FIG 11

Experimental production of the Monteggia type of fracture dislocation by pronation force In Figure 9 the limit of normal pronation has been reached Further rotation (Fig 10) caused a spiral fracture of the ulna and incomplete rupture of the orbicular ligament Figure 11 shows the forward dislocation completed

Experimental work—In an attempt to determine the mechanism of the anterior Monteggia fracture, experiments were carried out on eighteen dissecting-room specimens The procedure was as follows the soft tissues were removed from the elbow and forearm, leaving only the capsule and ligaments and the interosseous membrane, the shaft of the humerus was held firmly in a vice and the forearm was gripped in a wooden clamp just above the wrist and slowly pronated A typical experiment is shown in Figures 9 to 11 and the results are shown in Table I

In the twelve cases in which a Monteggia fracture was produced, it was interesting to find that the ulna always fractured first and as pronation continued the head of the radius was screwed forward out of its joint The capsule began to rupture slowly strand by strand and then suddenly split, allowing the dislocation to become complete

If these injuries are caused by a pronation force one would expect reduction to be achieved by supination This was observed consistently in the experiments (Figs 12–13) Whether the ulna was fractured or not, the head of the radius was reduced by supination—it was "screwed out" in pronation and "screwed home" in supination

FIG 12

FIG 13

In this experiment pronation caused dislocation of the head of the radius without fracture of the ulna Figure 12 shows the specimen in pronation with the radial head dislocated By supinating the forearm the dislocation was easily reduced (Fig 13)

CLINICAL MATERIAL

Monteggia fractures are uncommon and in the last two years the author has been able to collect only eleven This gives an incidence which corresponds roughly with that reported by Naylor The investigation and management of these cases were as follows Under general anaesthesia and with the patient lying supine the arm was held abducted at the shoulder and the elbow flexed 90 degrees Lateral radiographs of the forearm were take in supination, mid-rotation and pronation In most patients full supination reduced bo the superior radio-ulnar dislocation and the deformity of the ulna, with one excepti reduction was most nearly complete in supination When necessary, reduction was comple by traction on the hand and direct pressure over the radial head After reduction had be secured an above-elbow plaster was applied and the final position was confirmed rad graphically At the end of treatment the elbow was radiographed in three rotational positi to assess the stability of the superior radio-ulnar joint The results are summarised in Tabl and illustrative cases are shown in Figures 14 to 32

TABLE II

A SUMMARY OF ELEVEN CASES OF PRONATION INJURY OF THE FOREARM

Case	Age	Injury	Mechanism	Reduction	Result	Range of Rotation: Normal side, Supination	Range of Rotation: Normal side, Pronation	Range of Rotation: Injured side, Pronation	Range of Rotation: Injured side, Supination
1 W C	49	Simple Monteggia	Unknown	Supination	Union of ulna Radio ulnar joint stable	105	60	30	95
2 J P	17	Simple Monteggia	Fell from a tram Exact mechanism unknown	Supination	Union of ulna Radio ulnar joint stable	95	50	45	90
3 F J	62	Simple Monteggia	Knocked down by car Fell on to outstretched hand	*Supination and pressure*	Union of ulna Radio ulnar joint stable	90	40	10	90
4 W	8	Simple Monteggia	Fell off bicycle on to out-stretched hand	Open reduction at two weeks and supination	Union of ulna Radio ulnar subluxation	100	50	30	100
5 R M	5	Simple Monteggia	Fell off bicycle Exact mechanism unknown	Neutral rotation and pressure on head of radius	Union of ulna Radio-ulnar joint stable	Full			Full
6 C	7	Compound from within Monteggia	Fell at play Mechanism unknown	Supination	Union of ulna Radio-ulnar joint stable	120	70	70	120
7	6	Simple Monteggia	Unknown	Supination	Union of ulna Radio-ulnar joint stable	Full			Full
8 B M	71	Fracture lower third radius Superior radio-ulnar dislocation	Fell on to hand Mechanism unknown	Radius plated Radio-ulnar reduction in full supination	Union of radius Radio-ulnar joint stable	100	60	50	100
9 P	5	Anterior dislocation head of radius	Unknown	Supination	Stable	Full			Full
10 W	10	Separation upper radial epiphysis and anterior dislocation superior radio ulnar joint	Caught sleeve in machine hand rotated into full pronation and body twisted round several times	Open reduction in full supination	Stable	100	60	-50	100
11 J	3	Simple Monteggia	Unknown	Supination	Union of ulna Radio ulnar joint stable	Full			Full

The ranges of rotation movement are shown as one would see them when examining a patient The measurements were taken with Patrick s goniometer but mid-rotation is recorded as 0 degrees

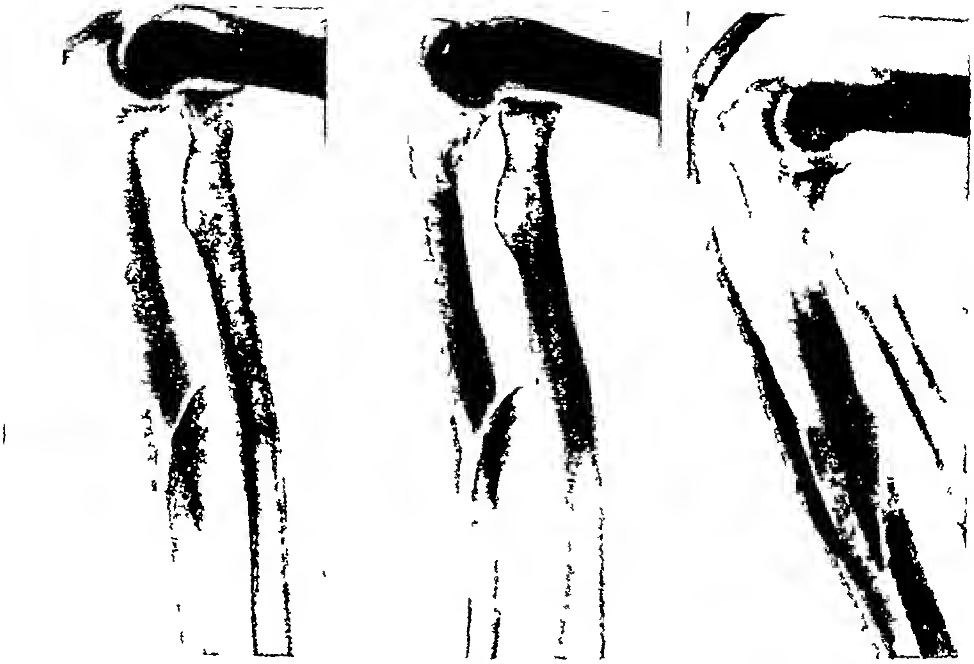


Fig 14 Fig 15 Fig 16

Case 1 W C aged forty-nine years Fracture of the ulna with anterior dislocation of the head of the radius Figure 14 shows the position in full pronation and Figure 15 in mid-rotation Reduction was secured only after full supination with long-axis traction (Figure 16) Note how the ulnar fragments fell together in this position

Fig 17 Fig 18 Fig 19

Case 1 *continued* Eight weeks later the fracture was united and the superior radio ulnar joint was stable in all positions of rotation Figure 17, full pronation Figure 18 mid-rotation Figure 19 full supination

FIG 20

FIG 21

FIG 22

FIG 23

Case 3 F J aged sixty-two years Anterior Monteggia fracture with maximal displacement of the head of the radius in full pronation (Fig 20) Full supination (Fig 21) even with long axis traction (Fig 22) failed to achieve reduction but with direct pressure on the head of the radius reduction was completed (Fig 23) In three months the longest period of immobilisation in this series the ulna had united and the superior radio ulnar joint was stable

FIG 24

FIG 25

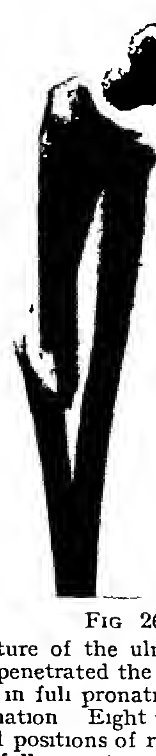


FIG 26

FIG 27

Case 6 J G aged seven years Compound fracture of the ulna with anterior dislocation of the head of the radius The upper fragment of the ulna penetrated the skin anteriorly well away from the subcutaneous border Figure 24 shows the position in full pronation and Figure 25 in mid-rotation Figure 26 shows the reduction secured by full supination Eight weeks later the fracture was united and the superior radio-ulnar joint was stable in all positions of rotation Figure 27 shows that there was stability in full pronation

FIG 28

FIG 29

Case 9 K P aged five years A case of anterior dislocation of the head of the radius without fracture of the ulna (Fig 28) Reduction was obtained by supination and immobilisation in plaster Eight weeks later the reduction was stable in all positions of rotation (Fig 29)

FIG 30

FIG 31

FIG 32

Case 10 B W aged ten years Severe pronation injury of the right elbow Anterior dislocation of the upper end of the radius with separation of the capital epiphysis (Figs 30 and 31) At operation, the superior radio-ulnar dislocation could be reduced only in full supination (Fig 32)

ANALYSIS

Several points may be emphasized

1) In nine of the eleven cases reduction of the superior radio-ulnar dislocation was achieved by closed methods and direct pressure on the radial head was required only twice When closed manipulation was successful, full supination was usually necessary to reduce the dislocation, but in one exceptional case reduction appeared to be more complete in mid-rotation and the limb was accordingly immobilised in this position

2) Two patients were submitted to operation In one case the fracture was two weeks old and closed reduction failed, in the other there was wide separation of the epiphysis of the radial head and operation was performed for its replacement In both cases it was observed by direct vision that the superior radio-ulnar dislocation was reduced by full supination and recurred when the forearm was pronated

Fig 33

Fig 34

Fig 35

Case 8 B M, aged seventy-one years An unusual case of fracture of the lower third of the radius with displacement and forward dislocation of the head (Fig 33) The antero posterior view of the tuberosity of the radius showed that the upper radial fragment was in neutral rotation (Fig 34) Because the reduction of the head of the radius needed full supination the fracture was first plated Three months later there was sound union and the superior radio-ulnar joint was stable (Fig 35) Despite the patient s age pronation was limited only 10 degrees and supination was full

3) At the end of treatment radiographs in three rotational positions showed that in ten cases the superior radio-ulnar joint was stable and in perfect position In the one case in which late open reduction had been performed (Case 4), there was slight forward subluxation of the joint in all positions of rotation

4) The fracture of the ulna united in all cases and the maximum period of immobilisation in plaster was twelve weeks

5) In ten out of eleven patients the final range of elbow movement was approximately normal In the case in which the radial epiphysis was replaced at operation (Case 10), the final range of rotation was much restricted This case is particularly interesting because of the history The patient was a boy aged ten years who caught the sleeve of his coat in the rollers of a machine His forearm was pronated with such force that he was picked up and whirled round twice before falling to the ground

CONCLUSIONS

1 Anterior dislocation of the head of the radius with or without fracture of the ulna is a forced pronation injury

2 Full supination is essential for reduction, and immobilisation in full supination is the surest safeguard against recurrence of the deformity

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RALPH CUMING AND THE INTERSCAPULO-THORACIC AMPUTATION IN 1808

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Surgeon Commander, R N (retd)
Keeper of the Library Royal College of Physicians London

And some there be which have no memorial,
Who are perished, as though they had never been —Ecclesiasticus

In October 1882, Paul Berger, who was surgeon at the Hospital Tenon and Professor of Surgery at the Faculte de Medecine de Paris, amputated the whole upper limb of a patient with an enchondroma of the humerus The next year he reported the result, and in 1887 published his classic work "L'Amputation du Membre Superieur dans la Contiguite du Tronc" This was the first detailed monograph on forequarter amputation and, in the historical review, Ralph Cuming was named as the originator of the operation Berger added that it had been performed only twice for war injuries, once by Cuming in 1808 and once by Gaetani Bey in Cairo more than thirty years later Meanwhile, in 1836, it had been used for the first time in malignant disease by Dixie Crosby in New Hampshire

In 1894, Cuming's priority was again recognised by W W Keen, Professor of the Principles of Surgery and of Clinical Surgery in the Jefferson Medical College Keen published his results and gave a full description of his own technique as well as that of others including Berger He reported another case in the following year Both Berger and Keen were generous in recording the priority of Cuming despite the lack of any original record of his case, and the same scrupulous honesty has persisted to this day Garrison gave him a place in the "History of Medicine," and Michael J Smyth acknowledged his claim in the Medical Press (1946) and the British Medical Journal (1948) In all these references Cuming remained little more than a name, and even the date that was attached was not always the same

Ralph Cuming was still a young man at the time of his death but there are many official reports of his work, many details of his life in the Service, and some account of the remarkable operation that he performed in the Naval Hospital at Antigua in 1808 As early as 1703 orders had been issued to Naval surgeons requiring them to keep journals and records of cases, and in 1731 there were further orders about these returns, but their value to posterity was not always recognised and many were destroyed, including all Cuming's journals The difficulties are increased by defects in the Surgeons' Register which does not record his appointment as surgeon's mate and includes no reference to his degree of M D, though this appears in the Monthly Muster Book of the Naval Hospital at Antigua, in February 1808, and also in his obituary notice

A Naval pay register shows that Cuming joined the *Raison* on July 16, 1795, and remained as her surgeon until November 1797 This was a period of discontent, with demands for improved medical care of seamen, culminating in the mutinies at the Nore and Spithead From the *Raison* he was transferred to the *Hind* in which he served till the summer of 1800 In neither ship did he see action or have much opportunity for surgery At that time the only provision for nursing was a berth situated against the forecastle bulkhead on the upper gun deck, or in the fore-part of the hold which was damp, unwholesome and filled with stench from the bilges At the close of the century Captain Markham of the *Centaur* designed the improved sick berth that came to be known by his name, but only four ships in the Channel Fleet had this accommodation at the time that St Vincent was appointed to the command Cuming was then appointed to the *Redoubt* and after six weeks was moved to the *Leyden*

Despite the constant actions of this period it was again his fate to be excluded from active combat and to miss the experience in emergency amputation that was gained by many naval surgeons

In February 1801, having left the *Leyden* a few months before she was sent by Nelson to Boulogne where casualties were sustained in action, Cuming was appointed to the Naval Hospital at Yarmouth Four months later, after perhaps gaining some surgical experience, he returned to sea, this time for a month in *Royal Oak* and then in the *St George* which had been Nelson's permanent flagship earlier in the year at the time of Copenhagen His next ship, *Ramillies*, had also been at Copenhagen, but again he had no casualties to treat The same fate attended him in *Malabar* of which he was surgeon for three months in 1805 He missed the action in which *Malabar* took part off Cuba in January 1806 and saw none throughout the year that he served in his last recorded ship *Pegasus* It appears that throughout his life at sea the most serious injuries that he treated were those from accidental explosion of guns while reloading—a cause of many compound fractures and amputations

These years must have seemed of little profit to Cuming, with his surgical bent, but there were many administrative reforms and changes in naval hygiene The practice by which surgeons procured their own drugs was discontinued in 1796 and, in the next year, tea was substituted for the afternoon spirit ration Preventive measures were introduced cinchona bark in wine was given to all men employed on shore in the West Indies in 1797 —a practice extended by Nelson to the Mediterranean station in 1803 The work of James Lind on scurvy had, at last, resulted in official prophylactic measures before he died at the age of eighty-three years (1799) The complacent acceptance of filthy conditions on the mess decks of ships, described so graphically by David Gillespie in his diaries, had given place to improved hygiene In 1800, Lord St Vincent issued an order for the airing of hammocks and clothing, which, if one may judge from recent experience, must have been very unpopular These were years of struggle for improved conditions of service, culminating while Cuming was in *Ramillies* with an Order in Council (January 22, 1805) establishing a uniform for surgeons and placing the medical service on an organised basis with relative ranks, though surgeons were only warrant officers As yet, however, there was no official plan by which surgeons at sea could improve the slender knowledge with which they had passed the examinations on entry, and the fact that Cuming had few opportunities for emergency surgical experience makes his achievement all the more remarkable He may well have felt that his professional lot was unhappy "*But we, brought forth and rear'd in hours of change, alarm, surprise—What shelter to grow ripe is ours ? What leisure to grow wise ?*"

Soon after he left *Pegasus*, Cuming's destiny changed In 1806, Matthews and Leigh of 18 Strand, London, published "Naval, Military and Private Practitioners' Amanuensis, Medicus et Chirurgicus " The author, Ralph Cuming, M D , R N , was styled "Medical Superintendent to His Majesty's Naval Hospital, Antigua" No copy of his forgotten Amanuensis can now be traced, the name of Cuming was not to appear in print for another twenty-three years, but then it was to be made memorable

In the London Medical Gazette, November 21, 1829, there was a long report by Mr J Luke of the London Hospital of an operation performed successfully by him in October 1828 (pp 235–239) He had removed three-quarters of the left scapula of a fourteen-year-old girl for sarcoma of the bone and it was said that she bore this formidable operation remarkably well "and did not faint" The account was read by a former naval surgeon, Mr A Copland Hutchison* who practised in Duchess Street, Portland Place, London, and the next week he sent a letter to the Gazette Through this chance correspondence we learn of Ralph

* Alexander Copland Hutchison F R C S author of "Hutchison s Surgery " and other works on surgery served in the Navy from 1801 to 1807 and from his experience at sea, wrote books dealing with casualties in action and diseases among seafaring people He became senior surgeon extraordinary to H R H The Duke of Clarence and was senior surgeon to the Westminster General Dispensary

Cuming's place in the history of surgery In his letter Hutchison drew attention to a case he had seen in 1808 at Greenwich Hospital

A young sailor about twenty one years of age presented himself for a pension on account of the total removal by operation of the arm, scapula and clavicle, and I perfectly remember our sending the man to the College of Surgeons or to some one of the London hospitals, to be there examined as to the successful result of this formidable operation Gun-shot wound, I think, was the injury inflicted, and the operation was determined on and performed by Dr Ralph Cuming, then surgeon of the Naval Hospital at Antigua "

In a subsequent letter, published on January 23, 1830, in the Gazette, Hutchison added that the case had been examined at St Bartholomew's Hospital He added that there was no doubt that the surgeon had removed the forequarter at operation and that it was not a case of traumatic amputation by the shot that wounded the seaman Cuming's priority in performing interscapulo-thoracic amputation rests on this evidence Hutchison gave no other details, and the few records of the Naval Hospital at Antigua that have been preserved shed no further light

From later reports of amputation it is possible to form an idea of the hazards of the operation It was in that year that new regulations had been issued for the Home Hospitals and if Cuming's patient had been at Haslar or Plymouth he would have benefited from the greater care then given to patients—bathing with soap and warm water, clean bed shirts, night caps twice a week, linen sheets fortnightly, hair mattresses, blankets and pillows The surgeon was urged " to soothe and cheer their minds by the most humane attention, to hear with patience all their complaints, to explain and redress as far as possible whatever they may think grievances, by every expression of consolatory kindness, which will naturally inspire them with confidence, exhilarate their spirits, and add to their hope of recovery, to which it cannot fail to contribute " One nurse was to be allowed for every seven patients, with provision for night nurses Hospital labourers cleaned instruments, prepared dressings, and attended patients when necessary

Nevertheless few of the amenities provided in the new regulations for Home Hospitals can have been available in the Leeward Islands " His Majesty's Naval Hospital at Antigua " was one of the many establishments that arose from the urgency of the times The prevalence of yellow fever kept this small hospital full, and Cuming gained experience of this disease for he was responsible for the care of fever patients in addition to British wounded and wounded French prisoners-of-war The buildings were placed on a low hill to the north-east of English Harbour, the dockyard on the south coast of the island which Nelson made one of his bases These various establishments were gradually closed down at the end of hostilities, and by 1815 all naval staffs and stores had been centralised in Bermuda But a map of Antigua, dated 1818, shows that the naval hospital was still in existence The staff was indeed inadequate it included only the surgeon, the second surgeon Robert Johnson, a clerk, matron, nurse, porter and barber, J B Douglas the dispenser, his negro assistant, and Pompee the watchman By day, the entire nursing requirements were met by the matron and nurse by night, " contractors' nurses " were hired to watch the sick The whole establishment was administered by the hospital agent who was responsible for all expenditure, he himself drew the highest pay Cuming's official pay was fifteen shillings a day, and three shillings and fivepence for rations, but he had so many allowances for other duties, such as attendance at the Yard, that in one quarter he was paid as much as £295, 12s $9\frac{1}{2}$d

Cuming was handicapped not only by limited nursing help but by primitive conditions and a tropical climate The risk of sepsis was obviously great Boiling of instruments after contact with septic cases had been advised in 1808, and knives were scalded because it was believed that warm instruments inflicted less pain than cold steel Opium or rum was sometimes used for analgesia but this was exceptional A piece of leather for his patient to chew may well have been given by Cuming when he placed the young sailor on the chair

With more consideration for the clothes of the patient than for his comfort it was usual to remove them entirely at this stage The assistants grouped themselves about the chair * John Woodall, in 1639, prescribed a minimum of five assistants Sir Charles Bell,† writing thirteen years after Cuming's operation, reduced the number of assistants to four and in his "Illustrations of the Great Operations of Surgery" (1821) gave a vivid description of amputation at the shoulder joint The legend to his illustration reads

1) The assistant or friend who supports the patient in his arms 2) A stout assistant who holds a sheet which is round the patient s body and who supports him against the pressure of the next figure 3) The assistant surgeon who stands behind the patient and who with his thumb, presses the sub clavian artery above the clavicle 4) A junior assistant should be seated here (on the floor) as much as possible out of the way of the operator His business is to hold the shattered arm to raise it, and move the humerus as the surgeon may direct during the operation 5) The operating surgeon, who now sees that everyone is in his place and knows his duty and understands to do what belongs to him, without bustle and without improper interference

Cuming had but one official assistant in hospital and moreover, for the technique of the operation he contemplated, he can have had no precedent It is true that in student days he must have studied Alanson's work on amputations, of which a second edition had appeared a few years previously He may have read Cheselden's description of Samuel Wood, the miller who in 1737 suffered traumatic right forequarter amputation while at work and was removed to St Thomas's Hospital the next day thus learning that gross mutilation was not incompatible with survival He may have foreseen the chief danger of the operation—air embolism of the subclavian vein We do not know whether he compressed the subclavian artery with a hard dry sponge above the clavicle, or whether he first resected the clavicle and ligated the vessels, both methods were used subsequently His next step would have been the formation of an anterior flap and division of the pectoral muscles and brachial plexus while the assistant made tense with his hands the structures to be divided A posterior flap would then be fashioned with separation of the soft parts from the scapula and rapid tearing of the tissues, held by strong linen or leather retractors as the upper extremity was dragged away Keen, in the age of anaesthesia, said that he took two hours to perform the operation in a case of malignant disease, but Cuming almost certainly subordinated everything to speed and used rapid sweeping incisions Bell stressed the need for decision and rapidity declaring that "the knife is to be handled more like a sabre than a surgeon's scalpel" Haemorrhage from so vast an area must have caused great anxiety, its control was entirely digital Close on half a century was to pass before another naval surgeon, Thomas Spencer Wells, working in the hospital in Smyrna during the Crimean War, introduced the forcep

* The identity of the patient cannot be definitely established but the Monthly Muster Book of the Naval Hospital at Antigua has two entries which are perhaps relevant Thomas Jones of the *Dominica* Quartermaster was admitted on March 11, 1808 he had an arm amputated and remained till April 22 1808 when he was discharged to the *Pulturk* for passage to join the Fleet bound for Europe John McInnes of the *Laura* was admitted on March 18, 1808 wounded by a shot in the left shoulder he was discharged June 16 1808 to the *Lily* for passage to Europe It will be noted that McInnes remained in hospital ninety days Jones forty-two days suggesting that the wound was more serious than the amputation There is no mention of amputation in the case of McInnes but this does not exclude the possibility of traumatic amputation before admission This view is supported by a statement by Samuel Cooper in his 'Dictionary of Practical Surgery' (Second edition 1813 p 483) 'I have lately seen in *London* a young sailor whose arm was completely torn off at the shoulder by a cannon-ball from one of the Forts at Guadaloupe in March 1808 he suffered no dreadful concussion of his body, nor were his senses at all impaired This case was very remarkable as the scapula was so shattered, that Mr Cummings of Antigua was under the necessity of removing the whole of it The patient recovered in two months *From* the account I heard I do not believe the axillary artery bled immediately after the accident The young man was lately shewn to the gentlemen at St Bartholomew s Hospital quite well The testimony of Samuel Cooper suggests that John McInnes was the patient However Copland Hutchison in his second letter to the London Medical Gazette already mentioned stated specifically that the amputation was not traumatic and his evidence was not further disputed This suggests that Thomas Jones was the patient

† Sir Charles Bell (1774–1842) graduate of Edinburgh anatomical writer and artist lecturer on anatomy and surgery in the School of Great Windmill Street, surgeon of the Middlesex Hospital Professor of Surgery Edinburgh

named after him Cuming had to grasp the great vessels between finger and thumb while his assistant placed a ligature about them Silk had displaced wax thread for this purpose, in accordance with the practice of French surgeons When the wound was finally closed, and the edges were held in accurate contact with adhesive straps, it was probably dressed with a poultice, a method that remained in favour until it was displaced by the absorbent dry dressings introduced by Gamgee in 1855 Over the poultice were placed broad and long straps of adhesive plaster reaching across the back and breast Finally a spica bandage was applied Such cases were usually dressed on the fifth or sixth day when " emollient cataplasms " were applied to correct the tension and inflammation Cuming would give his patient the customary thirty drops of laudanum, repeated twenty minutes later if there was no relief from pain It was usual to give wine every two or three hours " Symptomatic fever " was treated by purgation and barley water acidulated with *crem tartar* The healing of such a wound must have taken at least three months under the septic conditions in which Cuming worked The whole record may horrify the surgeon of to-day, and yet we must respect the confidence and courage with which Cuming extended the frontiers of surgery under such immense difficulties There is no doubt that he deserves a place in history with those of his great contemporaries

In all these Leeward Islands there are enclosures, seldom frequented, to which the curious stranger may be drawn by shaded solitude or the glimpse of an obelisk or pillared urn The dappled sunlight plays on inscriptions that record a great tragedy, for these are the graveyards of yellow fever It is not that special cemeteries were reserved for its victims but that sometimes this was the only cause of death The infection that decimated colonists, and swept away garrisons, cut down the young and vigorous Throughout the spring and early summer of 1808 the number of " fever " admissions to the Naval Hospital at Antigua increased steadily and in the first six months of 1808 they accounted for nearly all the 650 admissions The mortality was high and many patients were noted in the muster book as being in a dying state Epidemics were capricious, they appeared sometimes in the urban population and at other times among the plantation workers, Europeans, newly arrived in the island, might escape while the seasoned garrison succumbed, whereas at other times the new arrivals died in great numbers As late as 1866, when Thomas Nicholson published his " Essay on Yellow Fever," based on long experience in Antigua, it had proved impossible to arrive at any conclusion that would indicate the probable course of an epidemic, still less its cause Blood-letting and massive doses of calomel and quinine proved uncertain remedies, and the authorities agreed that, since nothing could be done, the chief duty of medical officers was to cheer the victims and maintain their spirits Cuming was a surgeon but he attended to the fever cases He attempted a new method of treatment—the application of cooling dressings soaked in rum In that climate they must at least have brought some relief and the results appeared to jurtify reports to the Admiralty Cuming wrote asking for bottles and utensils, he wanted a further assistant—a " Hospital Mate ", he wanted a General Inspector of the hospital, he asked that his work as physician should be recognised since the Board had stopped all private practice The many letters he sent to the Admiralty disclosed the strain under which he was working On February 8 he wrote on a more serious matter, sending an affidavit respecting an affray between himself and Captain Napier of the *Pulturk* The Board accepted his explanation and added, in their reply of April 7, that the iron cradles he needed were being sent, they asked to be informed further of his experiments on " Refrigeration with Rum " But in Antigua itself Cuming's relations were less satisfactory It may be that his many activities, and the emoluments arising from them, were a cause of jealousy, it may be that he was trying to do too much, that he was too direct in his methods, and that he was lacking in sensibility On February 9, 1808, he wrote to the Admiralty saying that the incidence and mortality of the fever could be reduced if certain local measures were taken He referred to the ease with which sailors could procure rum, to the debilitating

effects of exposure to the sun and excessively heavy work, to the laxity with which men were allowed to sleep exposed to the night air, to the excessive shore leave and inadequate nutrition, and to the need for substitution of bread for biscuits The soundness of his principles was established by the regulations that were framed later, but at the time they were probably no more than a source of irritation to the island authorities The whole unhappy position is revealed in a letter from the Commander-in-Chief, the Hon Sir Alexander Cochrane, Rear Admiral of the White, dated February 4, 1808 He informed the Commissioners of the Admiralty that the surgeon at the Naval Hospital at Antigua had been involved in disputes and quarrels ever since his arrival in the island, that his complaints were so frequent and voluminous that the Commander-in-Chief could not attend to them all, that he was "litigious," that he was heartless, that while still in their hearing he declared that patients would die, and that he performed his professional duties in an ungracious manner Cochrane asked that Cuming should be superseded There could be only one answer to such a letter, and a pencil note was scribbled on it by the Board to the effect that immediate action was to be taken Another marginal note on the letter states that Cuming was then dead

The incidence of yellow fever in the region of the Naval Hospital and chief military station in Antigua was high Thomas Nicholson, writing of the epidemic of 1849, remarked on how "indeed, the poisonous atmosphere appeared to be confined within very small limits," and it was within these limits that Cuming lived and that tragedy overtook him On June 24, 1808, young Ralph Cuming, his son, died, and the next day he himself died The notice that appeared in the Gentleman's Magazine for September 1808 is very brief and does not mention the infection that killed father and son There is no relevant entry in the hospital muster book except that R Johnson was appointed Surgeon on June 25 It is likely, however, that they died of the all-prevailing fever The obituary pays tribute "his loss will be severely felt a very skilful and able surgeon" and there, far from his home in Romsey, Hampshire, the story of Cuming's brief triumph ends It was only twelve years since he had been passed by the Company of Surgeons as second mate of a first rate "At a Court of Examiners holden at the Theatre the seventeenth day of April, 1796" He had more than justified the high estimate of his examiners

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FREDERICK OLDFIELD WARD

JESSIE DOBSON, LONDON, ENGLAND

Recorder, Royal College of Surgeons of England

Frederick Oldfield Ward entered the Medical School of King's College Hospital in October 1833, when he was fifteen years of age His parents resided at that time in Camberwell and his early education had been gained with a Dr Knox of Tonbridge His career as a student appears to have been successful enough and we know that he gained a medal in Chemistry in 1835 and a silver medal in Botany in 1837 While still a student he wrote "Human Osteology" which was published in 1838 In the preface he said that his book was the result "partly of researches in the museum and dissecting room, prosecuted at intervals during the last five years partly of a careful perusal and comparison of the best English and foreign works on the subject," and added that his aim in the work was brevity "But holding that true brevity consists not in expressing ideas in a small space but in conveying them in a short time, I have not thought it inconsistent with this design to dilate freely upon some obscure and difficult points which have been passed over in a few lines by previous writers Whatever contradictory statements came under my notice in the course of this comparison were noted down, and made the subject of careful research in several extensive anatomical collections which afforded me the opportunity of comparing nearly two hundred specimen of each bone"

The book is of small dimensions The pages of the first edition measure only two and three-quarters by four and a half inches, the volume being one and three-quarters inch thick Though it cannot be said to present the attractions of the modern text-book, its t and illustration achieve a degree of accuracy and a level of descriptive writing that is seld encountered even to-day

No record can be found of his taking the final qualifying medical examination but we know that for some years he practised as a surgeon His interests extended far beyond the confines of medicine In 1842 he published an essay on mosaic and tessellated pavement He became acquainted with Mowbray Morris, manager of the *Times*, and it was evidently arranged that Ward should write a series of articles for the newspaper on subjects of general interest Several of these dealt with the water supply of large towns, and in a letter to Mowbray Morris, dated October 16, 1849, he says "I hope you will not think me proud or wrong for mentioning this further fact—but I was assured (and I think not for flattery's sake but *bona fide*) that our sanitary articles have attracted special notice and are producing an extension of the sanitary power, etc The vast subject of this arterial organisation of tl metropolis is shaping itself in my mind I seem to see the intricate subterranean tub the heart-like engines—the inward flowing water—the outward *caput mortuum*—mapp itself underground and beginning to palpitate and live—as when incipient vitality first st the sleeping germ within the egg" An article on the fungoid theory of cholera appeared November 1849, and there were others relating to matters of public health

The fee agreed was five guineas per column, but letters written by Ward to Mowb Morris in 1850 reveal that the monetary arrangements were far from satisfactory to him stressed the great value of his contributions and their effect upon the public In July of t year he submitted a plan for the organisation of the newspaper "While recommende an extreme simplicity and facility of execution, it appears like to produce a profit of £ £500 to £1000 a year if adopted I am accustomed to think it fair and legitimate that a

who is not rich should profit by his devices, whether literary or industrial, and should you see no objection to the proposal I would agree to communicate this plan to the *Times*, leaving the Journal the option of adopting or rejecting it, on condition that, in the latter case the plan should not be divulged, and in the former that the resulting benefit should be equally divided between the proprietors of the *Times* and myself" Letters exchanged at this time between the Manager and Ward show that relations between them were becoming increasingly difficult and, indeed, their friendship would have ceased altogether had it not been for the intervention of Professor Partridge, of King's College Ward's connection with the newspaper, however, terminated at the end of July 1850

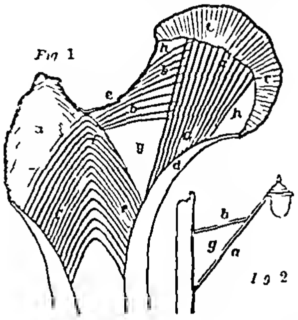
He took service as a clerk to Joseph Hume who introduced him to Edwin Chadwick, both of whom were pioneers of the new medico-legal group of sanitary reformers Fired with their enthusiasm, Ward wrote at this time a number of popular articles in which he criticised water supply and hygiene and proposed control under one central board of all sanitation in Great Britain Many papers were published at his own expense On September 20, 1852, he attended a Congress of Hygiene at Brussels and delivered an address entitled "*Circulation ou stagnation ?*" A contemporary writes speaks of him as "An able writer, a persevering speaker or rather reciter of his own pamphlets, with a special talent for claptrap phrases and the faculty of rapidly acquiring and employing, when addressing an uneducated audience, the technicalities or hard words of any science He began to study hydraulics (the most abstruse branch of engineering) when he became a drainage agitator and he knows just enough of the higher branches of arithmetic and mathematics to astonish and puzzle those who know nothing but he has two qualifications which serve him well—courage and connections"

At this time he also speculated in many small patents and it is said that unsuspecting tradesmen paid dearly for their infringement of forgotten patent rights of his inventions In 1854, on the recommendation of Lord Palmerston, Ward was appointed Commissioner of Sewers and evolved a plan for the drainage of London The theory was acknowledged to be excellent but was said to be impossible of execution it was described as the "quart-into-pint-pot" plan Political unrest at this period, combined, maybe, with his advanced and eccentric ideas, caused him to lose his office, though he apparently continued his investigations into the subject of water supply, for in September 1856 he addressed the International Congress of Public Health in Brussels and in the same year prepared the second edition of "Human Osteology" Two years later, a letter from Ward on purification of the Thames was published by William Coningham, Esq, M P, to whom it had been addressed Apart from this, nothing is known of his activities for almost twenty years though Sir John Simons, Medical Officer of Health for London, who had been a fellow-student at King's College, mentions in his "Personal Recollections" that before his death Ward suffered "enfeeblement" In 1875 Ward completed the third edition of "Human Osteology" His mental and physical powers deteriorated to such an extent that he entered St George's Retreat Lunatic Asylum at Ditchling, near Lewes, and died of general paralysis of the insane on November 15, 1877

Ward's experiments to show the nature and composition of bone provide interesting conclusions He studied the elasticity of the clavicle and wrote ("Human Osteology," page 284) "The clavicle has always been supposed to possess a certain elasticity in virtue of its double curvature, but no attempt, I believe, has hitherto been made to ascertain, by direct experiment, the amount of its resilient property I have endeavoured, by the following experiments, to obtain an approximate measurement of the elastic force resident in this bone A clavicle was taken from a well-developed, middle-aged, male subject, shortly after death, and laid upon a smooth surface, with its shaft perpendicular to the plane of a wall, against which its inner extremity rested Upon the outer extremity of the bone, thus disposed, a smart blow was now struck with a hammer, in the direction of its long axis The hammer rebounded from the end of the bone, which sprang to a distance of nearly two feet from the wall Mr Fergus of King's College, in whose presence the trial was made, suggested that the

effect might depend in some measure on the elasticity of the cartilage with which the ends of the bone were invested The experiment was repeated after the cartilage had been removed by scraping and thereafter the bone sprang as far, and sometimes even farther, than before Another experiment conducted on tissue from the centre of the lateral condyle of the femur was designed to show the strength of the reticular tissue, a cubic inch of which could sustain ' four hundredweight without sensible alteration ' "

which a is the principal support and b a cross piece tying a to the wall or column which sustains the whole It is evident that the piece a contributes by its *rigidity* and the piece b by its *tenacity* to the support of the weight



in other words that the weight tends to *bend* the former and to *stretch* the latter Referring to Fig 1 (in which the direction of the principal fibres is shown with fictitious

FIGS 1 and 2
Reproduced from page 370 of Human Osteology by Oldfield Ward

On page 370 of "Human Osteology," Ward illustrated the triangle in the neck of the femur with which his name is still associated (Fig 1) He wrote "The structure of the neck is shown at Fig 1 in the subjoined diagram It resembles in its mechanical principles a bracket of the kind represented in Fig 2 in which *a* is the principal support, and *b* a cross-piece tying *a* to the wall or column which sustains the whole It is evident that the piece *a* contributed by its rigidity, and the piece *b* by its tenacity, to the support of the weight, in other words, that the weight tends to bend the former, and to stretch the latter Referring to Figure 1 (in which the direction of the principal fibres is shown with fictitious distinctness—the cross filaments, etc, being purposely omitted) we find the pieces *a* and *b* of the bracket respectively represented by the sets of bony fibres marked *aa* and *bb* The fibres *aa* are inclined columns supporting the epiphysis of the head *cc* and resting below upon the thick wall *d* of the neck The transverse fibres *bb* decussate the columns *aa*, and tie them to the thin upper wall *e* of the neck, and to the arch-work *ff* of the upper extremity The middle of this arch-work presents a column of more condensed tissue, indicated by the shaded portion *f* in the diagram this results partly from the decussation of the convergent fibres, partly from the presence of several bony canals for the reception of nutrient vessels, that here descend vertically into the bone through orifices in the upper wall of the neck The interval *g* (which obviously corresponds to the intervals between the parts *a* and *b* of the bracket, Fig 2) is filled with a loose reticular tissue, presenting no determinate nor uniform arrangement "

A similar area is to be found in the calcaneum and Ward's description is as follows

"Thus, for example, a vertical section of the calcaneum from end-to-end exhibits the principal fibres radiating from the astragalar articulating surface—some horizontally backwards to receive the transverse strain of the great extensors of the foot—a considerable number obliquely downward and backward, to transmit, through the tubercles of the heel to the ground, the pressure received from the astragalus—while a third set run forward, diverging from each other as they advance, to strengthen the greater process As, however this bone is subject to no directly vertical pressure, nor to any strain which direct vertical fibres would help to resist, so we find no such fibres in the cancellous structure but in their place (between the fibres that descend obliquely backward and those which descend obliquely forward) an empty triangular interval The same economical distribution

FIG 3
Ward's triangle in the calcaneum

materials is observed in all the tarsal bones, and it accounts for the great resisting power which they possess in proportion to their weight "

Ward was particularly interested in the special structure of bone whereby its strength was increased He made this observation " The arrangement of the cancellous tissue in the ends of the femur is very remarkable, and, as it illustrates the general mechanical principles which determine the structure of this tissue throughout the skeleton, it should engage our particular attention In the lower extremity of the bone, it consists of numerous slender columns, which spring on all sides from the interior surface of the compact cylinder, and descend, converging towards each other, so as to form a series of inverted arches, adapted by their pointed form to sustain concussion or pressure transmitted from below These converging columns not only meet but decussate each other, and they are further strengthened by innumerable connecting filaments and laminae, which cross them in all directions, so that no single arch could break without those in its neighbourhood also giving way Hence, notwithstanding the tenuity and brittleness of each several fibre, the reticular structure possesses great strength as a whole "

FIG 4
Ward's triangle in the neck of the femur

Ward's account of the triangle in the neck of the femur attracted little attention for many years, but the introduction of roentgen rays showed clearly that the translucent triangular area was a normal feature of the femoral neck (Fig 4) Mention of it appeared in text-books It is unfortunate that in " Text-book of X-ray Diagnosis," edited by Shanks, Kerley and Twining, Ward's triangle is defined wrongly (Volume III, page 289) Ward's triangle in the calcaneum is shown in Figure 3

I would like to express my gratitude to Mr Maywood, Librarian of the *Times*, for permission to read and reproduce extracts from Ward s letters

FROM AN ATLAS OF GENERAL AFFECTIONS OF THE SKELETON

11 ACHONDROPLASIA

Synonyms—Chondrodystrophia foetalis, Micromelia

H A THOMAS FAIRBANK, LONDON, ENGLAND

Achondroplasia is a congenital condition resulting from interference with enchondral ossification and is characterised by dwarfism of the short limb type, associated with a large head and, in many cases, so-called "trident hands" It is the commonest type of dwarfism and perhaps the most ancient there is clear evidence of its existence several thousand years ago Although he was not the first to recognise that this affection was distinct from rickets, it was Parrot (1878) who suggested the descriptive title, achondroplasia The term chondrodystrophia foetalis was suggested by Kaufmann in 1892 Even in recent years many cases have been reported as examples of achondroplasia which really belong to the chondro osteo-dystrophy group, while numerous "atypical" cases have been published which at present it is impossible to classify

As to its frequency, Caffey (1948) reported that at the Babies' Hospital in New York City forty-three achondroplasiacs were identified radiologically in the course of fifteen years, in the same period there were fifteen cases of osteogenesis imperfecta, fourteen ateleiotic dwarfs, ten cases of gargoylism and nine of multiple exostoses (diaphysial aclasis) Achondroplasia undoubtedly occurs in certain animals, but it is no longer regarded as a satisfactory explanation for the stunting of limb-growth in all short-limbed species A lethal form of the disease has been reported in rabbits (Brown and Pearce 1945)

Hereditary and familial influences—These are apparent only in a minority of cases, but achondroplasia has been traced through as many as six generations in the male line (Phemister 1924) Most cases—nearly 90 per cent of the series studied by Morch (1941)—are sporadic Nevertheless there is a 50 per cent chance that a child, one of whose parents is an achondroplastic dwarf, will also be affected Difficulties in labour in the female achondroplasiac interfere with inheritance It has been met with in twins, one or both being affected

Sex—Females are rather more frequently affected than males Rischbieth and Barrington (1912) found seventy females and fifty-six males in the series they investigated

Age—The characteristics are present at birth, whereas in cretinism and chondro osteo dystrophy the special features, including the dwarfism, develop after birth It is usually said that most die before, at or soon after birth, which is often premature at about the eighth month The maternity hospital records examined by Morch showed that 80 per cent of affected children died during the first year of life In view of these statements it is curious that the patients that survive are so singularly sturdy and robust, and that they live to an advanced age

Etiology—Achondroplasia results from a developmental fault inherent in the ovum, the cause of which is entirely unknown Of the various explanations that have been suggested none has received general acceptance The failure of normal ossification of the long bones is apparent in the foetus towards the end of the second month, or early in the third month of foetal life This fact, and the occurrence of the condition in only one of a pair of twins eliminates the possibility of an endocrine error as the cause It affects all races and, as already mentioned, it occurred in prehistoric times This is one of the conditions which Jansen (191 suggested were the result of excessive intra-uterine pressure caused either by hydramnios or a small amnion, but if this is true, how is it that most cases are so singularly true to type

Clinical features—These are obvious at birth, whether the child is alive or dead Dwarfism is the most striking feature, the reduction in height being due chiefly to shortness of the lower limbs When adult life is reached and growth ceases the height is usually less than four feet and may be as little as two feet six inches The mid-point of stature is always above

the umbilicus and may be as high as the lower end of the sternum Although the spine is affected to some extent, the limbs are strikingly short in comparison with the trunk The fingers may not reach below the greater trochanters The shortness of the lower limbs may enable a child to kiss his toes with ease when standing The proximal segments of the limbs —the humeri and femora—are more affected than the distal segments (rhizomelic micromelia) The head is large and brachycephalic, and suggestive of hydrocephalus which may be present in mild degree, though it is not progressive (Dandy 1921) The frontal region is rather prominent and the bridge of the nose is depressed and flattened The lips are often thick and during the early months of life the tongue may protrude The mandible may be somewhat prognathous Dentition is normal The spine may be lordotic but is often surprisingly flat, the apparent lordosis being due more to the unusual prominence of the buttocks than to excessive curvature of the lumbar spine This deformity does not flatten out as the child is laid on its back, not even when the hips are fully flexed There may be a kyphotic curve in the dorsal region The chest is small and flat, the ribs being abnormally short with perhaps some "beading" at their anterior extremities (Parsons 1936) the costal cartilages are unaffected The breadth of the shoulders is up to the average Movements of the shoulder joints and supination of the forearms may be somewhat limited (Caffey 1948) Fixed abduction of the upper limbs, with limitation of adduction, has been reported Extension of the elbows may be limited in one case examined, extension was checked at 120 degrees

The hands are short and broad, and frequently, but not invariably, they display a typical deformity The middle finger is short and the fingers are more nearly of equal length than in a normal hand The digits, which are all rather short and thick, diverge, the space between the second and third fingers being particularly wide thus is formed the "main en trident" of Marie (1900) The legs are often bowed, except in younger children in whom they are usually straight and only occasionally valgoid The bowing, associated in some cases with hyperextension of the knees, is due mainly to curvature of the tibiae, the deformity occurring usually, but not invariably, in the upper part of these bones Correction of deformity by osteotomy may be justifiable, but is seldom necessary The head of the fibula lies abnormally high The general appearance of the limbs is one of sturdiness with some enlargement of the ends of the bones The musculature is often above the average these patients may perform feats of strength and be able to rise from the floor in one movement (Parsons 1936) The gait is rolling—probably because of the backward tilt of the pelvis and the posterior displacement of the hip joints, it is certainly not due to coxa vara, though it is often stated, quite incorrectly, that this deformity is always present

The skin is thick and the soft tissues generally seem to be too long for the limbs so that, in younger children, folds and furrows are formed between rolls of fat The abdomen is rather large and prominent Intelligence is normal, but the subjects of achondroplasia may be affected psychologically by their difference from other children or by the curiosity they invoke if they join a performing troupe Sexual development is normal, or it may be somewhat excessive

Although in most cases the whole skeleton is affected, the impairment of growth is occasionally of a more limited distribution, exceptionally the dwarfism is even confined to one limb The author has seen a woman with both humeri dwarfed to a marked degree while the forearms, lower limbs, head and body were all of normal size

Blood examination reveals nothing abnormal

Radiographic appearances—The long bones are short, strong and rather dense The femora and humeri may be less than two-thirds of the normal length The curves and muscular impressions are exaggerated The shafts may be thickened but usually the increase in diameter is more apparent than real and is due to the reduction in length The medullary canal is reduced in size and may be obliterated by cancellous bone Splaying of the ends of the shafts is more abrupt and obvious than in normal bones and the terminal surface is irregular In some of the major long bones, notably in the region of the knee joint, the end

of the shaft is notched centrally to form a V-shaped surface The epiphyses appear to be large but as a rule they are not abnormal in size They may begin to ossify somewhat early while fusion with the shafts shows great variation, occurring either early, late or at the normal time A striking feature is the position of the epiphysial centre close to the end of the shaft, and tucked into the apex of the V-shaped notch of the metaphysis when this is present The two limbs of the notch may appear to embrace the epiphysis—an impression that is confirmed by histological examination In young children the position of the epiphysial centre so close to the diaphysis results in considerable increase in depth of the joint space as seen in radiographs (Fairbank 1934) In a stillborn infant there may be such shortness of the diaphyses that more than half the length of the limb is formed by the epiphyses (Khoo 1945) The clavicles and fibulae are much less affected than other long bones The relative excess in length of the fibula may be regarded as a persistence of the condition that is said to be present normally at the eighth month of foetal life The fibular head lies higher than usual occasionally it may even participate in the formation of the knee joint Sometimes the shaft of the fibula is bowed The ulna, on the other hand, is occasionally shorter than the radius, as it may be in several other general affections of the skeleton The ribs are short—sometimes even less than half the normal length The sternum is short, broad and thick, and the sternal angle is increased The scapula is deformed, its shape suggesting that the inferior angle has been cut off, and the glenoid is too small for the humeral head The pelvis is reduced in size in all diameters The ilium, especially in adults is small and the crest is thickened In children the lower part of the ilium, above the acetabulum, is broader than normal and the bone as a whole is of a curious shape The hip joint lies farther back than usual, so that the acetabulum abuts on the sacro-sciatic notch Sometimes the pubic arch is unusually wide The sacrum is narrow and tilted to an abnormal degree, its promontory protruding more than usual into the pelvic cavity Coxa vara is often stated to be common, even "invariably" present, but this is not supported by examination of radiographs

The skull is large the sella may be small The characteristic feature is premature fusion of the pre-sphenoid, post-sphenoid and basi-occipital, to form an os tri-basilare which is abnormally short As a result there is considerable diminution in length of the base of the skull The foramen magnum is small and funnel-shaped, its diameter may be reduced to half the normal The facial bones are unaffected The vertebral bodies may be somewhat reduced in depth but the total reduction in length of the spine is much less marked than that of the limbs Reduction in size of the ossific centres for the vertebral bodies was regarded as a constant feature by Parrot (1878), but the bodies are never noticeably shallow and the kyphotic curve is long and gradual Nevertheless angular kyphosis, suggestive of that met with in the two types of chondro-osteo-dystrophy, was seen in two undoubted cases of achondroplasia examined by the author in one patient only two years old the deformity almost disappeared on standing

Progress—Even when fusion of the epiphyses is delayed, adults are always far below the normal in height

Pathology—There is relative aplasia of cartilage at the ends of the long bones Growth of all cartilage cells of the epiphyses is disorderly According to Harris (1933), mucoid degeneration of the cartilage is "the underlying feature" It may be degenerate, fibrillar, vacuolated and unusually vascular There is absence of the normal columnar palisade arrangement at the epiphysial line, and provisional calcification is erratic The spongiosa is irregular and tends to be dense, with the cartilage cores diminished in calibre or entirely absent (Caffey 1948) Harris regards the shafts as the serial summation of lines of arrested growth Periosteal ossification is normal or excessive The periosteal ferrule "outstrips and overlaps the cartilage-formed bone" (Keith 1919) This explains the radiographic appearance in which it was noted that the cortex of the metaphysis appears to embrace the adjacent part of the epiphysis An important feature, often but not invariably present, is the ingrowth

from the periosteum of a vascular fibrous band or layer between the zone of ossifying cartilage at the epiphysial line and the rest of the epiphysis, if, as occasionally happens, this fibrous layer extends across the whole diameter of the bone, further growth of the shaft must necessarily cease According to Knaggs (1927) this band may be formed by metaplasia of the cartilage The thymus, thyroid and pituitary show no constant changes

Death at or shortly after birth is attributed either to the inadequate capacity of the thorax or to excessive reduction in the size of the foramen magnum It has been said that general oedema and ascites may cause difficulty at birth

Diagnosis—Achondroplasiacs display their typical features at birth, whereas infants with either of the two types of chondro-osteo-dystrophy usually pass as normal for the first one to four years of post-natal life, and owe their dwarfism to the spine rather than to the limbs, moreover in these dwarfs kyphosis, rather than apparent lordosis, is the rule In the Morquio-Brailsford type of chondro-osteo-dystrophy the head and face are normal, while gargoylism is distinguished by the heavy facies, mental deficiency, corneal opacities, and enlargement of the liver and spleen In cretinism the characteristic features are not recognisable at birth The only condition that is likely to simulate achondroplasia at birth is osteogenesis imperfecta in a severe pre-natal case of this condition, the subject, whether alive or dead at birth, may display marked shortening of the limbs as compared with the trunk, but radiographic examination at once settles any doubts as to the diagnosis Short limbs at birth may also be seen in dysplasia epiphysialis punctata, but this is an exceedingly rare condition with unique radiographic features

FIG 52

Case 17 Typical achondroplasia in a female infant Note that the dwarfism is due chiefly to shortness of the lower limbs —not the trunk The mid-point of stature is at the lower end of the sternum The fingers reach only to the greater trochanters The soft tissues of the limbs are too long for the bones so that there are many cutaneous creases and rolls of fat

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CASE 18—ACHONDROPLASIA

(Figs 53–57) Male, aged seven years Typical case Some limitation of extension of the hips Extension of the elbow joints limited Subluxation of the head of the radius, particularly in the left elbow the subluxation occurs on flexion, the radial head resuming an approximately normal position on extension Outer ends of clavicles bent down (Under Dr R S Frew)

Fig 53

Figs 53 and 54

Case 18 Typical short-limbed dwarf (Fig 53) with large head, prominent forehead depressed bridge of nose small flat chest and prominent abdomen long dorsi-lumbar kyphosis with minimal true lordosis but with prominent buttocks and relative shortness of all four limbs particularly the proximal segments (rhizomelic micromelia) Figure 54 shows the unusual shape of the ilia and the absence of coxa vara though the femoral necks are prolonged inwards at the epiphysial lines Note the short femoral shafts splayed at the extremities particularly the lower which show the typical central notches into which the epiphyses fit

Fig 54

Fig 55

Case 18 Hands showing typical trident deformity and thick digits

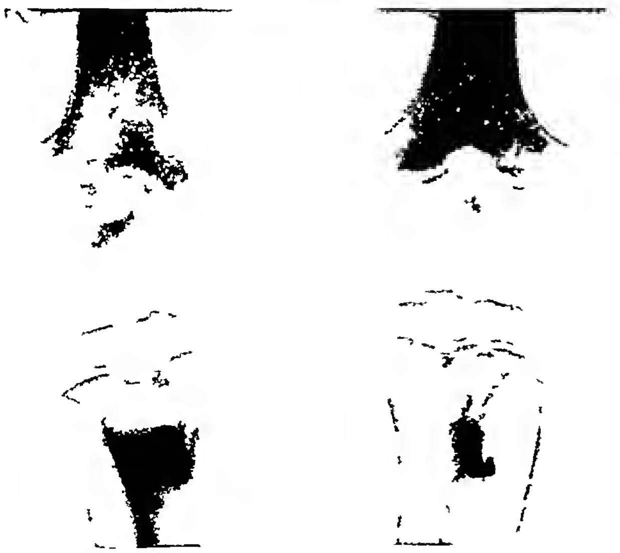

Fig 56

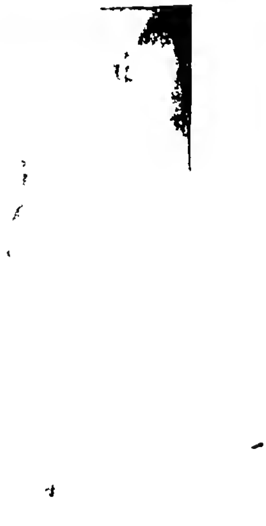

Fig 57

Case 18 Note the marked splaying of the metaphyses of the femora and tibiae (Fig 56) the central notches particularly in the femora the close proximity of the epiphyses to their respective shafts and the wide joint space in both knees The upper limb (Fig 57) shows the stout shaft of the humerus with an unusual shape of the extremities of the bone The radial head is in an approximately normal position, the elbow being extended to the limit

CASE 19—ACHONDROPLASIA

(Fig 58) Female child, aged seven months, who displayed all the features of achondroplasia There was some asymmetry both upper limbs were relatively short, as also were the lower limbs, but the left upper limb was shorter than the right The head was large There were trident hands with pointed fingers There was a low dorsal kyphosis (Under Dr R S Frew)

Fig 58

Case 19 Radiograph of the leg shows the position of the epiphysial centres in the region of the knee joint close to the ends of the shafts and not in the middle of the cartilaginous epiphyses Note the apparent widening of joint spaces

CASE 20—ACHONDROPLASIA

(Figs 59 and 60) Female, aged five years Typical case

Fig 59

Case 20 Lower limbs showing the typical short stout bones with splaying at the extremities irregularity of the ends of the metaphyses and characteristic position of the ossific centres Note the length of the fibula the head is abnormally high in both legs at the ankle joint the fibula reaches rather lower than usual

FIG 60

Case 20 Pelvis and hips showing the same curious shape of the ilia as seen in Figure 54 Note the flat horizontal roof of the acetabulum on both sides The femoral necks show some lipping on the inner side but are not varoid

CASE 21—ACHONDROPLASIA

(Figs 61 and 62) Female, aged five and a half years Typical case, clinically and radiographically, except that the spine displays deformity that is suggestive of the chondro-osteo-dystrophies (Under the late Sir Henry Gauvain)

FIG 61

FIG 62

Case 21 Photograph shows the typical features of achondroplasia (Fig 61) The lateral view of the spine shows the twelfth dorsal body slightly wedge-shaped forming the apex of an angular kyphosis Note that the shape of the vertebral bodies differs both from that seen in the Morquio-Brailsford syndrome and from that typical of gargoylism

CASE 22—ACHONDROPLASIA

(Figs 63-65) Female, aged two years Below normal height for her age Relative shortness of the limbs especially the proximal segments Head large facies not typical Intelligence normal Hands trident Slight limitation of extension of the elbow joints Angular kyphosis of the spine with apex at dorsi-lumbar junction on standing the kyphosis almost disappears Radiographic appearance of long bones and of ilia is typical of achondroplasia The lower ends of the scapulae are square, as if the angles had been cut off

Fig 63
Case 22 Thorax and shoulders with arms elevated to show the curious square 'angles of the scapulae

Fig 64

Fig 65

Case 22 Pelvis and lower limbs showing the typical shape of the ilia femora and tibiae (Fig 64) Lateral view of the spine shows angular kyphosis at the first-second lumbar level but without features typical of either type of chondro-osteo-dystrophy

12 CRANIO-CLEIDO-DYSOSTOSIS

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This congenital condition is characterised by deficient formation of the clavicles with delayed and imperfect ossification of the cranium, associated in many cases with other anatomical errors The first case of clavicular defect is said to have been reported by Martin (1765) One, with both clavicles and the skull affected, was reported in 1871 by Scheuthauer Marie and Sainton (1898) named the condition hereditary cranio-cleido-dysostosis and called attention to irregularities in the dentition For long it was thought that the changes were confined to bones that normally ossify in membrane but, in fact, bones preformed in cartilage are often affected

In view of the widespread and variable abnormalities discovered in cases that might be regarded as belonging to this group, Rhinehart (1936) suggested the alternative title of mutational dysostosis—a suggestion that was supported by Soule (1946)—but this seems to be much too comprehensive a title Three valuable reviews of the subject have been published by Fitzwilliams (1910), Fitchet (1929) and Soule (1946)

Hereditary and familial influences—Heredity undoubtedly plays an important part in the incidence Stocks and Barrington (1925) found that the condition was inherited in more than half the cases they collected, namely in ninety-six of a total of 144 It has been traced through five generations (Soule 1946) but it is said as a rule to disappear after two or three generations It may be inherited through either parent with about equal frequency Soule combining Fitchet's figures with his own, found that in a total of 323 cases 198 were familial these occurring in fifty-two families, while 125 cases were sporadic

Sex—Both sexes are affected to an approximately equal extent

Age—It may be discovered at any age The cranial deficiencies may be noticed at birth Fitzwilliams' cases included a baby one month old and a woman of sixty years The defective clavicles cause little if any disability and may easily escape notice for many years but nearly 70 per cent of the reported cases were discovered before the age of twenty years

Etiology—The cause of this primary error of development is entirely unknown It is one of the conditions that Jansen (1921) attributed to increased intra-uterine pressure, but his theory has not been generally accepted There is no doubt that the development of the clavicles must be disturbed at a very early stage of foetal life It has been discovered in a twin, a girl, the other twin, a boy, being normal

Distribution of the abnormalities—This shows considerable variation The clavicular error is present almost without exception and is usually accompanied by deficiency of the cranium Defects in the skull appear to be always symmetrical As to the clavicles, one or both may be defective Fitzwilliams found a unilateral defect in only six of sixty ca[ses] Stocks and Barrington found bilateral defects in 82 per cent of their cases, only two patients both with typical changes in the skull, had normal clavicles Other sites of developmental errors are the teeth, the mandible, the hands and feet, the pubis, the femoral necks and the neural arches Paltauf (1912) seems to have been the first to note the gap in the pubic symphysis Crouzon and Bouttier (1921) suggested that a case with deficient ossification of the pubis be labelled *forme cleido-crânio-pelvienne*, while Latham (1945) proposed the term cranio-pubo-dysostosis for a case with normal clavicles

Clinical signs—The striking features of a typical case are the slender build, the large head with small shrunken face, long neck, drooping shoulders and narrow chest Growth of the whole skeleton is retarded and there may be a certain degree of dwarfism, but this is r

marked feature as a rule The mentality is normal In at least one-third of the cases the skull shows well-marked frontal prominences separated by a median gutter The parietal bones and sometimes the occipital bone may also form prominences, making six bosses in all on the skull (Stocks and Barrington 1925) The orbital ridges are well marked but the lower margins of the orbits are shrunken or even deficient The anterior fontanelle is large and may never close completely In some of the younger patients a much greater deficiency in the calvarium is seen The eyes are rather far apart The palate is high A mild degree of hydrocephalus may be present The maxillae are small so that the relatively large mandible may be prognathous Delayed eruption, non-eruption and incomplete development of the permanent teeth are common The temporary teeth erupt well and may be retained longer than normal, but when they are shed the retention of permanent teeth within the jaws may necessitate the wearing of dentures Supernumerary permanent teeth are sometimes present Dentigerous cysts may occur

As a rule, the defects in the clavicles are easily felt Sometimes there is no more than a kink in the middle of the bone or merely a dimple of the skin The position of the shoulders —low and a little forward—and their abnormal mobility are no more than would be expected Though the muscles may be defective in some anatomical details their power is not usually diminished Many patients reach adult life entirely unaware of the defect in spite of hard manual work involving heavy lifting Noticeable weakness of the shoulders and a tendency to undue fatigue are exceptional When both clavicles are affected the shoulders can be approximated voluntarily in front of the chest to an abnormal degree and can be made to meet by gentle passive force The scapulae may be small, somewhat deformed, rather winged and prominent, and more mobile than normal Subluxation of the humeral head has been found in a few cases The dislocation was complete in one case (Gross 1903), and could be easily completed by manipulation in another We found both humeral heads subluxated downwards in a boy aged seven years Bilateral subluxation of the radial heads has also been reported Unusual length of the first finger is not uncommon The fifth metacarpal may be shorter than normal The terminal phalanges and the nails are short, particularly in the thumbs and great toes

Other skeletal abnormalities have been found in individual cases Postural defects and spinal curvature are common Spina bifida occulta, often widespread in the spine, is of no clinical importance Syringomyelia has been found as a complication Widening of the symphysis pubis and deficient ossification of the pubic bones are not obvious clinically and even when sought are often not palpable In younger patients the pubes are present, though partly or completely devoid of ossification Coxa vara can be recognised by the usual signs Other deformities that have been reported in individual cases are subluxation of a hip or a finger joint, and absence of the radius In a case with deficiency of only one clavicle there was bilateral synostosis of the radius and ulna (Avery 1930)

Radiographic appearances—*Skull*—The membranous calvarium shows various degrees of imperfect ossification The base is ossified normally The sutures often fail to close normally The anterior fontanelle is large and may never close, it may reach nearly to the level of the orbital ridges even in an adult Occasionally there is a larger defect anteriorly, even in middle life A fontanelle may be present posteriorly in both mastoid regions and also in the sphenoid The mastoid itself may not be pneumatised (Salmon 1944) Wormian bones are seen in the occipital and posterior parietal regions The frontal sinuses are often absent but occasionally they are disproportionately large, the other sinuses being small In extreme cases there may be no ossification whatever in most of the vault In one of our patients, aged three years, the two parietals were apparently unossified The pituitary fossa may be small but it shows no constant change The maxillae are hypoplastic but the mandible is of normal dimensions fusion at the mandibular symphysis may be delayed or even fail to occur There was no sign of fusion in a boy aged eight years reported by Ingham (1947) The mental tubercles

may be unusually long The nasal, lachrymal and malar bones may be incomplete or absent (Salmon 1944) In some cases ossification of the skull is normal

Clavicles—Stocks and Barrington (1925) found that the commonest defect was absence of the outer end of the clavicle, the sternal half being present The next commonest condition was the presence of two separate fragments for each clavicle (28 2 per cent —but this figure seems unduly low) The inner fragment was usually the larger of the two the outer may not reach the acromion The least common defect was absence of the sternal end with the acromial end present Complete absence of both clavicles was uncommon (8 1 per cent) and absence of one clavicle only was exceptional These findings are supported, more or less by other authors Stocks and Barrington found pseudarthrosis between the two fragments in only three cases the adjacent ends of the fragments in such cases may be enlarged or they may overlap In only two of their cases, both with typical skull changes, were the clavicles normal Nettesheim (1926) reported the case of a woman aged twenty-nine years with the left clavicle in three pieces and the right in two Everley Jones (1937) rightly called attention to the need for care in examining radiographs since a clavicular fragment may easily be overlooked In ten cases with clavicular defects this author found both clavicles represented by two fragments in all but one in this there were two clavicular fragments on one side and only the sternal portion present on the other The bones of the *limbs* generally are rather slender In many of the recorded cases it seems probable that the pelvis and hips were not specially examined, so that the frequency of abnormalities in this region is uncertain

Pubes—In most cases no reference is made to the condition of the pubes In the author's small series of eleven cases, ten, varying in age from three to eighteen years, showed deficient ossification of the pubis, the deficiency being bilateral in all In the other case—an adult woman—the pubes were well ossified, but her two affected children both showed defects of the pubes as well as other signs of dysostosis The degree of deficiency was found to vary In three patients there was complete absence of ossification in the pubes, both body and rami The oldest patient of this group was a boy aged fifteen years who showed some stippling in the pubic part of the acetabulum In six of the remaining seven cases there was a fragment of bone of varying size in the horizontal ramus, the body and descending ramus being completely unossified Ossification of the pubis is only delayed, it occurs eventually, though often incompletely The inferior ramus of the ischium shares in the delayed and defective ossification The symphysis may remain unusually wide with an irregular boundary on each side In such cases the fusion of the conjoint rami may be incomplete and their thickness considerably reduced The case of a woman aged twenty-four years with these changes in the pelvis, and gross deficiencies in the clavicles, was reported by Steel and Whitaker (1937) Imperfect or delayed ossification of the pubes is not, however, invariably found in cases showing other clear signs of the condition For instance, Fitchet (1929) published six cases in three generations of a family, in all of which the pubes were normal and there was no coxa vara The pelvic ring may be reduced in size but seldom to a sufficient degree to cause trouble in childbirth The sacro-iliac joints may be increased in width

Coxa vara—In the author's series of eleven cases there was coxa vara in five—bilateral in three, unilateral in two Both clavicles were deficient in four of these patients the fifth had unilateral coxa vara and a defect of one clavicle, both on the same side of the body, while failure of ossification of the pubis was present on both sides The type of coxa vara seems to vary Klar (1906), the first to record this deformity, called the coxa vara in his case "congenital" But Ollerenshaw (1938) considered this type unusual In his opinion the deformity occurred in the upper part of the femoral shaft and he had not seen coxa vara of the infantile type in the "many well-marked cases" of cranio-cleido-dysostosis he had seen The author's experience differs from this, for in every case with coxa vara (a total of eight abnormal hips) the deformity was invariably of the infantile or cervical variety (Fairbank 1927, 1928) Soule (1946) said that infantile coxa vara was common In Crouzon ...

Bouttier's case (1921) the acetabula were deformed and the mobility of the hip joints was much increased

Spine—Failure of union of the neural arches is common and may involve several vertebrae in the dorsal and lumbar regions In one case we found spina bifida occulta from the sixth cervical to the sixth dorsal vertebra In younger patients the vertebral bodies are inclined to be biconvex and the discs biconcave in older patients they may show some reduction in depth Various other congenital deformities of the spine, including half vertebrae and incomplete or complete absence of the lower part of the sacrum and coccyx, have been reported, but such exceptional findings are of little interest and of no diagnostic significance Eltorm (1945) reported a curious case, a woman aged fifty-two years, with the dorsal bodies wedged *posteriorly* and showing defective ossification The ribs may slope downwards to a greater degree than usual The sternum may be of peculiar shape failure of the manubrium to ossify has been recorded

Hands and feet—In the hands and feet, various abnormalities have been found, the most constant and curious being the presence of epiphyses at both ends of the metacarpals and metatarsals, particularly of the second and fifth, and an abnormally long second metacarpal The epiphysis which occurs at the base of the second metacarpal is strikingly large The ungual tuberosities are poorly developed or absent, the terminal phalanges being short and pointed, particularly in the thumb and great toe (Brailsford 1935) The intermediate phalanges may be small, they may show curious ossification or even be absent Ossification of the carpus may be delayed The calcaneum may be short

Complications—Pressure on the brachial plexus, relieved by removal of the outer fragment of the clavicle, was reported by Poynton and Davies (1914) One patient who complained of pain and numbness in the ulnar area, accompanied by cyanosis, was treated by bone-grafting operations on both clavicles (Everley Jones 1937) Ollerenshaw (1938) reported two cases, a brother and sister, with calcification in the skin and soft tissues Syringomyelia has been mentioned already as a rare complication

Pathology—There is no abnormality in the bone of the calvarium and clavicles except the limitation of its distribution The base of the skull is said to be narrowed, especially in the middle portion The cranial bones are thickened where bosses occur The muscles acting on the shoulder girdle show a number of abnormalities varying with the type of clavicular deficiency (Fitzwilliams 1910, Everley Jones 1937) Their relative frequency corresponds broadly with that of the various deficiencies of the clavicle The commonest are absence of the clavicular portion of the trapezius and the anterior fibres of the deltoid Occasionally the sterno-mastoid and pectoralis major are deficient, but the clavicular parts of these muscles are affected only when the sternal part of the clavicle is very small or completely absent—a rare occurrence When the sternal portion alone is present the bone is prolonged outwards by a ligament or fibrous band which in most cases passes to the coracoid and not to the acromion The ligament may even be attached to the glenoid or to a rib (Fitzwilliams) it is regarded as the costo-coracoid membrane When there are two fragments these are usually united by a ligament

Diagnosis—This should present no difficulty Absence of ossification of the pubis may be of diagnostic value If found by accident it may lead to the discovery of deficiencies in the skull and clavicles In a young patient showing pseudarthrosis of a clavicle, with thickening of the fragments, and without obvious deficiency in the skull, radiographic examination of the pelvis might remove any doubts as to the case being due to an error of development and not to trauma Evans (1924) reported the case of an infant with an absent tibia and complete absence of ossification in the femoral head on the same side and in the pubis on both sides The condition of the clavicles is not mentioned but the skull appears to have been normal

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CASE 23
CRANIO-CLEIDO-DYSOSTOSIS

(Fig 66) Tracing of the radiograph published by Steel and Whitaker showing the wide symphysis and imperfect ossification of the pubes and conjoint rami in a woman of twenty-four years There were deficiencies in the skull, and absence of the outer two-thirds of both clavicles

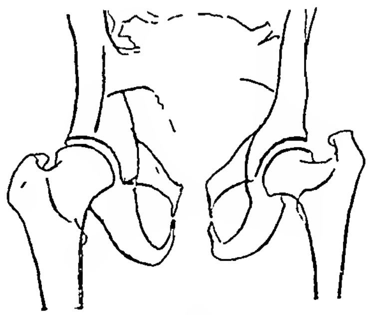


FIG 66

CASE 24—CRANIO-CLEIDO-DYSOSTOSIS

(Figs 67–73) Male, aged seven years One of a family of seven children, the others being normal Has always presented the same general appearance with large head and narrow shoulders Typical changes in the skull, clavicles, pubes, hands and feet Anterior and temporo-parietal fontanelles patent and membranous, frontal and parietal eminences prominent Marked frontal fissure No sign of frontal sinuses which should be visible at this age Wormian bones in the occipital region Lambdoid suture closed Teeth very irregular On extraction of carious temporary teeth there was practically no absorption of the roots The shoulders can be "bunched together" The right shoulder droops more than the left, radiographs showed that the humeral head was subluxated downwards

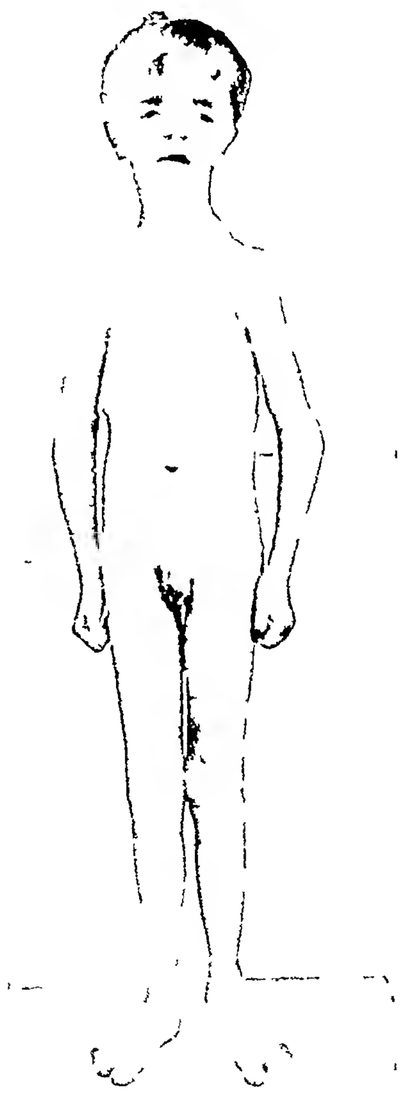


FIG 67
Case 24 Large head, small face narrow shoulders and chest slender build generally Note that the head of the right humerus is lower than the left

FIG 68
Case 24 Posterior view—small and markedly winged scapulae

FIG 69
Case 24 Antero-posterior radiograph of the skull showing the large anterior fontanelle The metopic suture is widely open in its upper two-thirds

FIG. 70

Case 24. Chest and shoulders showing the narrow thorax. The right clavicle is represented by two fragments and the left clavicle is deficient in its outer part where it fails to reach the acromion.

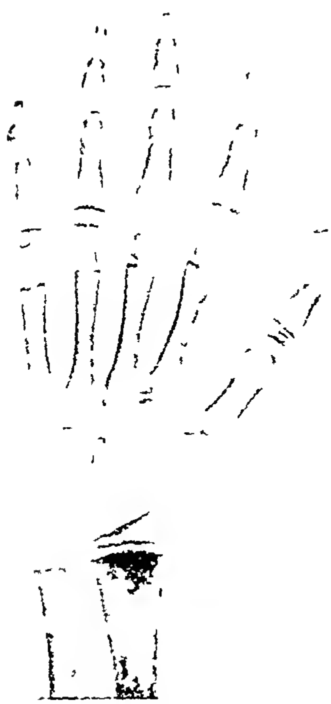


FIG. 71

Case 24. Hand showing delayed ossification of the carpus, epiphyses at the bases of the second and fifth metacarpals and abnormal shape of the intermediate and terminal phalanges.

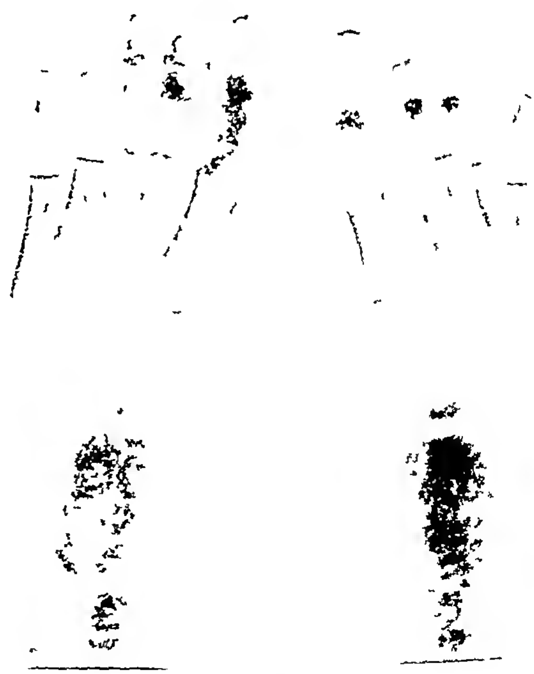


FIG. 72

Case 24. Feet showing additional epiphyses at the bases of the second metatarsals. The shape of the internal cuneiforms and of the phalanges, particularly of the great toes, is abnormal.

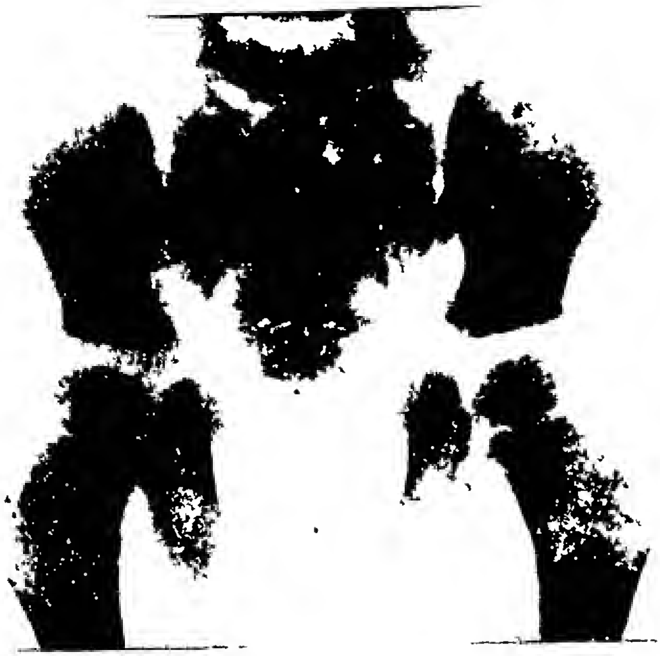


FIG 73

Case 24 Pelvis and hips showing absence of ossification in the bodies and descending rami of the pubes and delayed ossification in the inferior rami of the ischia The horizontal pubic rami are represented by oval fragments of bone

CASE 25—CRANIO-CLEIDO-DYSOSTOSIS

(Fig 74) Female with bilateral clavicular dysostosis, each clavicle being represented by two fragments Skull apparently normal (but not radiographed) Pubes ossified but distinctly less dense than the rest of the pelvis No coxa vara The width of the symphysis is approximately normal The patient had three children, two affected by dysostosis both had bilateral clavicular dysostosis, all four clavicles being in two fragments In the elder child, a boy aged twelve years, there was no ossification of the pubic body or descending ramus on either side, whereas the horizontal rami consisted of bone, there was coxa vara on the right side only, the only abnormalities in the skull were absence of the frontal sinuses and presence of Wormian bones in the occipital bone The younger child, a girl, showed similar bilateral delayed ossification of the pubis but no coxa vara

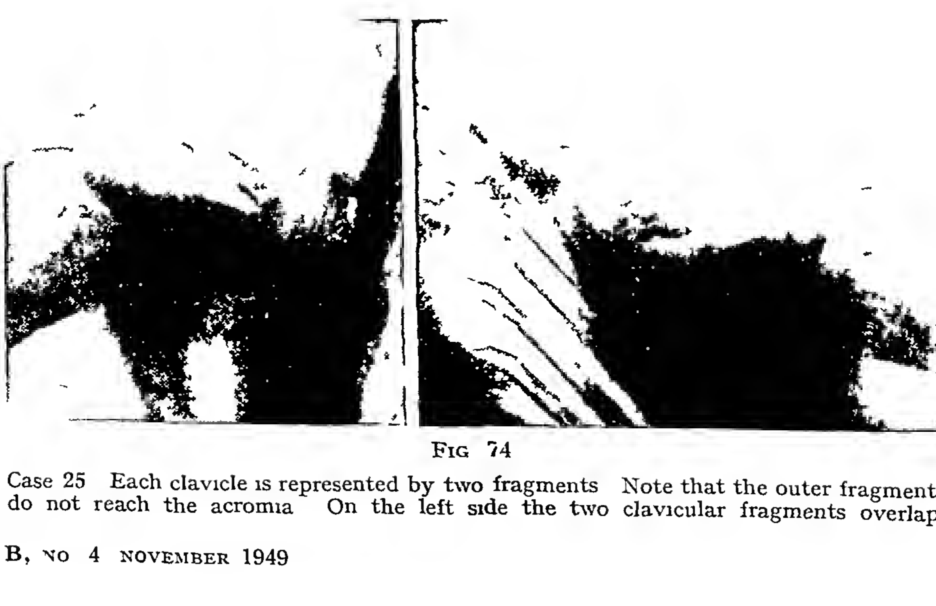


FIG 74

Case 25 Each clavicle is represented by two fragments Note that the outer fragments do not reach the acromia On the left side the two clavicular fragments overlap

CASE 26—CRANIO-CLEIDO-DYSOSTOSIS

(Figs. 75 and 76.) Female, aged six years. Always weak on legs; gait waddling. Lordosis present. Skull generally well ossified. Wormian bones in the occipital region. Bilateral division of the clavicle into two fragments. Bilateral coxa vara, which radiographs showed to be of the cervical or infantile type. Subtrochanteric osteotomy performed on both femora. The body and descending ramus of the pubis, and the ascending or inferior ramus of the ischium, are unossified on both sides. The horizontal rami of the pubes are ossified. On palpation no deficiency can be felt in the pubic region. Additional epiphyses and other changes present in the hands. The terminal phalanges of the toes, particularly of the great toe, are typical.

FIG. 75

Case 26. Thorax and shoulders showing both clavicles in two fragments, the outer being smaller and not making contact with the acromion.

FIG. 76

Case 26. Pelvis and hips showing absence of ossification in the bodies of the pubes and the conjoint rami and typical infantile coxa vara of both femora. Note that the horizontal rami of the pubes are ossified.

CASE 27—CRANIO-CLEIDO-DYSOSTOSIS

(Figs 77–80) Male, aged three years No abnormality noticed by the parents Fourth of four children, the others and the parents being normal Gross deficiency in the calvarium, the parietals show little if any signs of ossification, anterior fontanelle very large Two fragments for each clavicle Epiphyses at both ends of all metacarpals Ossification of carpus delayed Both pubes completely devoid of bone No coxa vara Delayed fusion of mandibular symphysis and of neural arches of the spine The density of most bones is below normal (Under Sir L Barrington-Ward)

Fig 77

Fig 78

Case 27 Skull showing enormous fontanelle, limited union of the two halves of the frontal bone and absence of fusion at the mandibular symphysis (Fig 77) In the lateral view note the gross deficiency in ossification particularly of the parietals and many Wormian bones in the occipital (Fig 78)

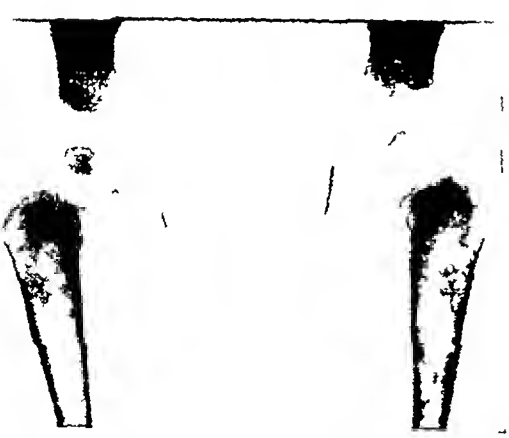


Fig 79

Fig 80

Case 27 Pelvis showing complete absence of ossification in the pubes and inferior rami of the ischia (Fig 79) The lower forearm and hand (Fig 80) shows osteoporosis of the bones double epiphyses for all metacarpals and a curious shape of many phalanges

IN MEMORIAM

THOMAS PORTER McMURRAY, C B E , M Ch , F R C S

1888-1949

The suddenness with which we have lost the alert vitality of T P McMurray with hi boyish good humour, tall, handsome presence, and perpetual appearance of youth is difficult to believe Until recent months he was still teaching post-graduate students from Australi Canada, South Africa and many other parts of the world, and only a few days ago when th Hugh Owen Thomas Lecture was delivered in Liverpool he welcomed " a lost sheep " back t the fold He died from a heart attack in London on November 16, while on his way to Sout Africa to visit his son

Born in Belfast, McMurray graduated in medicine at Queen's University in 1910 and th next year went to Liverpool as house-surgeon to Sir Robert Jones In 1914, after serving for a short time in France as captain in the R A M C , he was recalled to the Alder H Military Orthopaedic Hospital in Liverpool where many English, Canadian and Americ surgeons were trained by Robert Jones and worked with him McMurray's clini appointments at the David Lewis Northern Hospital, Royal Liverpool Children's Ho

and Ministry of Pensions Hospital were coupled with University teaching appointments first as lecturer and then, in succession to Robert Jones, as director of orthopaedic studies When a chair was established in 1938 he became Liverpool's first professor of orthopaedics, and after upholding the traditions of Hugh Owen Thomas for a quarter of a century he was made emeritus professor last year He was honoured by the presidencies of the British Orthopaedic Association and the Liverpool Medical Institution, and was president-elect of the British Medical Association

He was essentially a good companion Whether in the operating theatre where none was immune from his wit, on the golf links where he sank ridiculously long putts without appearing to look at the ball, at home playing cards where he always seemed to win, or at a fair throwing at coconuts and smashing a whole stand of crockery for an outlay of half a crown, he was great fun When doing nothing he did it thoroughly, and to see him sitting in the sun at his beloved Ystrad "cottage," gazing at the Denbighshire hills, was an education in relaxation His kindness was warmed with an emotion that he himself would have denied For six years after the loss of his first wife he was a very lonely man, but then the wound healed and after marrying again he enjoyed life more and more To his wife and daughter, and to his son now practising orthopaedics in South Africa, we offer our deep sympathy

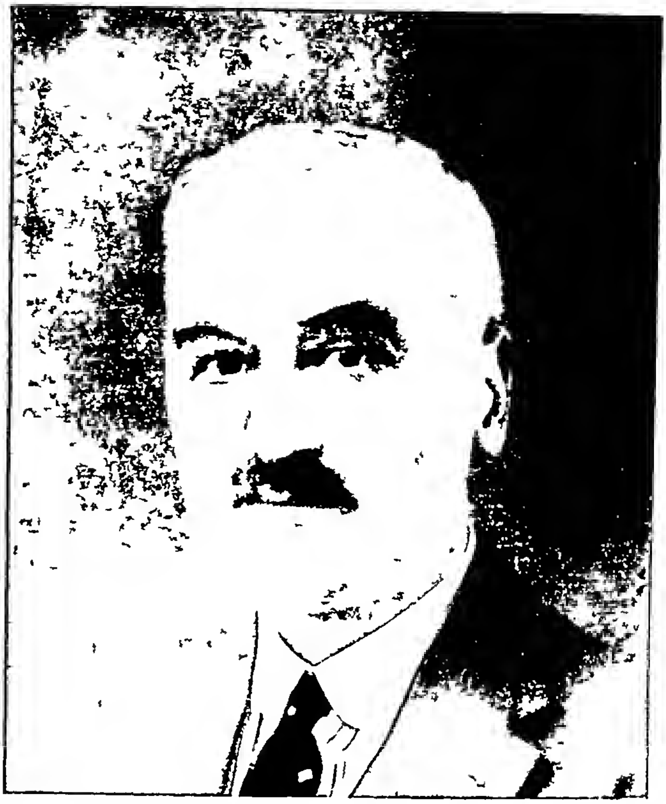
In McMurray was exemplified British reluctance to commit clinical observation to writing until confirmed after many years His writings were therefore few, but they were important Some may still find difficulty in eliciting his sign for posterior horn tears of the meniscus, and others may wonder why oblique displacement osteotomy avails in the treatment of osteoarthritis of the hip, but none may discount his conclusions which were based so firmly on long observation

His dexterity as an operator is almost legendary Many have seen him remove a meniscus with the whole of its posterior horn in less than five minutes, and recent American visitors spoke of the fleetness of foot that was demanded of assistants chasing round the operating table when a hip joint was disarticulated in little more than ten minutes But it was the consummate skill and artistry of his technique that was even more impressive than the speed of it, the speed was indeed "an achievement and not an aim"

It is as a teacher that McMurray will be remembered He was forceful, dogmatic, and even intolerant if the principles of Hugh Owen Thomas were denied "You've read that in a book" he would say with reproof He was not an orator, but his words will long be remembered "Feel it laddie", "I think you're splendid", "Get on with it laddie", "You're a credit to us" The building up of a great postgraduate school of orthopaedic studies, with the M Ch Orth degree of the University of Liverpool, is the permanent contribution he made to the surgery of his generation It is difficult to know the full extent to which he maintained and enhanced the Liverpool tradition of orthopaedic surgery but a measure of it is in the words of his old students, from the four quarters of the world, inscribed in a recent presentation volume

"This book is signed and presented by your old students as a symbol of their respect and affection and to record for ever the debt they and their country owe to you By your skill and by your teaching you have enhanced a great tradition this is now our treasured heritage and by our deeds we will preserve it"

B McF
R W-J



ROBERT MILNE, M D , M S , F R C S , L M S S A
1881-1949

Robert Milne, son of Dr Milne of Inverurie, was born in 1881 and educated at the City of London School He began his medical studies at the London Hospital eighteen years later The many scholarships and prizes he gained showed his calibre Taken by themselves they were impressive enough, but in the light of the opposition he had to face they were doubly so, for these were the embryo days of the growing distinction of the London Hospital His friends and contemporaries included the surgeons Russell Howard, Richard Warren, Frank Kidd, James Walton and Henry Souttar, and among those who were to be distinguished in pathology and medicine were Hubert Turnbull, Theodore Thompson, Charles Miller and Letheby Tidy

He qualified in 1904 at a time when a man could hold appointment after appointment year after year, so that whatever speciality he might adopt later his foundations were sound and secure This Robert Milne did He held appointments in general medicine, surgery, gynaecology and obstetrics, served in the casualty and out-patient departments, and was resident anaesthetist and assistant in the ophthalmic, ear, nose and throat, and orthopaedic departments In 1910 he was appointed sixth assistant surgeon, and joined forces with Hugh Rigby in the firm of " Rigby & Milne " His appointment as Teacher of Elementary Clinical Surgery in 1914 was restricted by absence on military service when he served as a major in the R A M C

In 1922 Tommy Openshaw retired and Robert Milne inherited the Orthopaedic Department of the London As the treatment of fractures remained in the hands of the general surgeons, few came under his care, but he set a high standard Not unnaturally considering his contacts in the first war, he favoured the methods of Meurice Sinclair and really knew how to use them He could almost make a Thomas splint talk and he was an artist with Sinclair's glue A bandage in his hands was no mere swaddling, it exercised its control where he wanted it Let it not be thought that he was a conservative diehard His work and hospital were almost his only interests and he was always on the alert for new things

That he did not find as many as might have been expected was because his encyclopaedic knowledge of what had gone before often showed him that the latest marvel was no more than an old dodge resurrected

His clinical memory was astounding and social recollections often hung from a clinical peg "Ah, boy," he would say, confronted by a half-remembered face "Yes, yes, Princes Risborough, 1913 wasn't it, you fell off your horse into a pigsty and we fixed your fractured femur in a Thomas splint that the blacksmith made from an old iron bedstead?" Thus were the years spanned and to him the "History" really mattered—an aspect of medicine that he taught assiduously to generations of students

In one other respect Robert Milne was outstanding He had a vast and detailed knowledge of every type of industrial activity If a patient said that he was a "radial driller" Milne knew his work exactly How great an asset to one whose life was devoted to the restoration of function, and how much it contributed to his judgment!

Between the wars Milne became ever more busy, succeeding his father as consulting surgeon to Dr Barnardo's Homes, serving on the Court of Examiners of the Royal College of Surgeons, examining for the University of Cambridge and the Society of *Apothecaries and* attending at the London Hospital where his clinics and operating theatre were always packed with students and postgraduates

In 1942 came the day of his retirement But the limbo of oblivion was not for him The next day, having shaved off his moustache with what unknown pangs, he appeared in the uniform of a surgeon rear-admiral From then he was consultant to the Royal Navy and after early falterings as to who saluted whom and when, he was accepted into its family circle

Kindly, generous, courteous and human, it was impossible not to like him His impish sense of humour could never give offence He was modest and unassuming, he wrote little, and it is to be regretted that he hid his light under the bushel of the London Hospital Those who worked with him remember the great debt they owe At the age of sixty-eight, while still in full vigour, he played a round of golf, and quite suddenly was spared the sorrows of failing health To his widow and three children the most sincere sympathy of all who knew him will go out

O J V-J

GABRIEL NOVE-JOSSERAND
1868-1949

By the death of Professor Nove-Josserand of Lyons on October 15, France has lost one of her greatest leaders and pioneers in orthopaedic surgery He was honoured the world over His pride and joy when awarded the Honorary Fellowship of the Royal College of Surgeons of England in 1933 was witnessed by this writer and will never be forgotten Until the very end, he was eager to know of the latest developments of orthopaedics in Great Britain

He was born in the vicinity of Lyons in 1868 and devoted a busy life to the treatment of disabled children in that city In early days at a secondary school, and throughout a remarkable University career until the highest degree in the Faculty of Medicine had been gained, he won every single prize that was offered As a pupil of Leopold Ollier he acquired interest in bone surgery and the physiology of epiphysial growth After beginning practice as a general surgeon he was appointed head of a service in the *Hopital de la Charite* at the early age of twenty-nine, which is unusual in France At that hospital there were some fifteen or twenty children suffering from congenital deformities and this was the turning point in his career One of the first surgeons in France to conceive of orthopaedics as a special branch of surgery, he shared with Muirhead Little, Openshaw, Elmslie, Bankart and other British colleagues the task of winning for our specialty the recognition it now commands

GABRIEL NOVÉ-JOSSERAND
1868-1949

Never sparing time or effort, and with ceaseless attention and steadfast devotion to his Service, he became established as a leading pioneer From Vienna he brought to France the teachings of Lorenz on congenital dislocation of the hip His own contributions included a technique for the treatment of congenital club-foot, an operation for congenital malformations of the urinary tract, the first arthrodesis for coxalgia, and monographs on coxa plana, infantile paralysis of the knee, and deformities of the foot that are still worth reading

During the 1914–18 war he served as specialist with the rank of colonel and organised a service for the restoration of disabled soldiers in civil life—one of the first of its kind in France In 1920 he was appointed the first Professor of Orthopaedic Surgery in the University of Lyons He presided over the French Orthopaedic Society in 1922, and ten years later, in London, was made president of the International Society of Orthopaedic and Traumatic Surgery—a tribute to long and splendid service

He was a great teacher Generations of medical practitioners and many well-known orthopaedic surgeons gained stimulus and inspiration from him Lectures were planned with unusual care and particular attention to detail, and demonstrations were made effective by the skill with which he handled children and the precision and conciseness of his diagnosis

Gabriel Nove-Josserand was a magnificent figure, tall, lean, composed and with a stately bearing His private and family life was characterised by quiet dignity By nature he was silent and reserved, he never uttered an observation that was not deeply matured, and his authority was based on supreme integrity and wonderful modesty After retirement a few years ago he maintained a keen interest in the development of orthopaedic surgery, with a mind that was still open to new and original thought A long and painful illness was met with unflinching courage and composure He was a great surgeon and a great man W B

UNITED STATES OF AMERICA, CANADA AND GREAT BRITAIN

THE SAGA OF THE "DEEP FREEZE"

AN AMERICAN VIEW OF CONTEMPORARY BRITISH ORTHOPAEDIC SURGERY

The American orthopaedic group arrived at Southampton on March 22 With customary British efficiency we were whisked through customs by representatives of the British Orthopaedic Association and on into London There began the most concentrated period of instruction clinics lectures sight-seeing and entertainment that the British could conceive In the next six weeks we were whirled through the length and breadth of Britain in a bus affectionately named the "Deep Freeze" We visited some thirty-three hospitals and six rehabilitation centers in eighteen cities An appraisal of contemporary British orthopaedic surgery, consequently is not at all presumptuous Elaboration and detail would make a large and delightful volume and still be only a synopsis of the astonishing number of instructive and

The American and Canadian travellers in orthopaedic surgery who are joint contributors of this report on contemporary British orthopaedics photographed on board the ' Queen Mary '

entertaining features of this trip We wish that every young American orthopaedic surgeon could ride the British surgical carousel it is doubtful however if a group a decade or so older could survive the terrific pace of British hospitality We are tremendously grateful to our British hosts and hostesses we are thrilled with admiration for their scientific accomplishments we are happy to know personally our British contemporaries in orthopaedic surgery

During the trip it was difficult to appraise and digest all the information properly The tendency to see the leaves rather than the trees in the Sherwood forest produced deep-freeze conversation of an exaggerated character which might well have disturbed British-American relations A sufficient period of time has now elapsed for proper rumination and reflection Certain features of the trip have become hazy but very pleasant memories and the outstanding performances will never be forgotten We are quite convinced that British orthopaedic surgery is superlatively ' well done '

What is the difference between British and American orthopaedic practice ? Basically and fundamentally there s very little difference The problems are much the same and the over-all approaches are essentially similar ' You ll find that many of our orthopaedic problems are not handled as well as in America but our trauma is better handled That British opinion would find considerable American support, others would reverse it A view of both countries shows that social, economic and medico-legal factors dictate some of the differences Hospitals equipment physical resources and even socialized

Some of the boys outside—

—and inside the " Deep Freeze "

medicine play a part If these factors are eliminated there's only a small residual pot-pourri of provocative subjects On some of these we disagreed among ourselves as much as with our British hosts In general our British friends are a bit less surgical-minded than we in their approach to a few orthopaedic or traumatic problems

Not all the advances and knowledge of medicine have occurred in the past half century A stroll through the museums of the Royal Colleges of Surgeons at London and Edinburgh reveals a [illegible] of enviable anatomic and surgical specimens The original works of such great men as Hunter Pott [illegible] and Harvey leave one in awe and amazement—almost reverence The British surgeons have a tremendous rich heritage, their anatomists are among the best Their rather numerous references to great men of the past are now not only understandable but commendable

In addition to their skill as surgeons and anatomists we were impressed by their ability as first class speakers and orators, either at social functions or scientific sessions. This is certainly one small facet that Americans have neglected. At the British orthopaedic meeting in Nottingham, it was a treat to hear men talk in a clear, concise manner and present their subjects clearly without notes in the allotted time. Verbosity is reserved for social functions, particularly the after dinner speeches.

The hospitals in Britain were of two extremes: either old, chilly structures with high ceilings, or extremely modern and up to date buildings. Obviously in every instance the surgeon conferred with the architect for the operating theaters were well planned and very large. Some were, in fact, of "movie set" material, namely beautiful tile, excellent taste in colors and gorgeously equipped. The many open-ward hospitals reflect the influence of Sir Robert Jones and Dame Agnes Hunt. We wondered if the capillaries of the attendants ever expanded to normal. One had to admit that they all looked superbly healthy and didn't seem to mind the cold. In fact the lack of central heating in most hospitals and homes didn't seem to inconvenience anyone (but the visitors).

The geography of Britain lends itself to well organized clinics scattered radially about the principal orthopaedic centers. Their cases are followed in a very detailed manner by both surgeons and clinic nurses. The average orthopaedic follow-up nurse in Britain is a well-trained orthopaedic assistant who has considerable ability, experience and knowledge. The clean, neat wards and well cared-for patients, particularly those with chronic disease, speak well for British orthopaedic nursing. Soiled appliances or apparatus were a rarity.

Rather than run the gamut of orthopaedic surgery we've picked a few subjects in which our group was particularly interested. Poliomyelitis is not included for it is not a major problem in Britain, nor were any well-organized efforts observed in behalf of cerebral palsy; neither do we mention slipped upper femoral epiphysis since we couldn't even agree among ourselves as to the details of proper therapy. All of our group have contributed and, in the main, concur in the following syllabus.

Congenital Anomalies

Discussions on congenital dislocation of the hip were held at some half-dozen centers. The method of treatment varied slightly in the different clinics visited but, in general, was similar to the methods favored in America. In the infant patient, closed reduction under general anaesthesia, with or without a preliminary period of traction, was the most common procedure. Subsequently, immobilization was carried out by means of a plaster cast with the legs in the frog, or 90-90, position. The change to the secondary position of internal rotation was usually delayed a little longer than is our practice, namely, between three to six months after the primary reduction. At a few centers the Batchelor splint with traction was used to obtain a gradual reduction by abduction and to provide fixation thereafter for a varying period. Final fixation was ordinarily secured by a plaster cast.

We found few advocates of derotation osteotomies or of primary open reduction, this latter procedure being reserved for resistant or older conditions. Shelf operations were highly favored and many were done at an early age. Pre-reduction arthrograms with radiopaque material were being made with great frequency in many of the clinics and provided some very definite clinical information, but added little to definitive treatment.

Treatment of the older patient with unreduced dislocation and resultant pain is much the same on each side of the Atlantic. Most of these patients come to osteotomy or some other type of reconstruction operation and with very similar results to our own.

Congenital club-feet were seen in about the same frequency in Britain as at home, and because of well organized and well-distributed orthopaedic clinics, most patients received treatment early in life. In general it was our impression that the treatment of the early defect in Britain differed considerably from the current methods being used in America. Mild deformities are treated by repeated manipulation, frequently at home, with intermittent fixation either by adhesive strappings, a cast, or the Denis Browne splint. Application of the latter was not carried out unless the foot could be passively corrected to the neutral position. When this was not possible application of the splint was preceded by manipulation with the patient under anesthesia. The plaster wedging method of Kite which has become so generally accepted in this Continent was not in use at any of the clinics that we visited. The more resistant and difficult conditions were usually treated by forceful manipulation or an open operation, and we thought that the Kite method would be a very beneficial addition to their armamentarium. Forceful manipulation, as with our early experiences, left much to be desired; it left a rather inflexible, broad, short foot.

The older, recurrent and resistant condition of the feet became operative problems. Medial soft-tissue excision operations combined with lengthening of the heel cord or posterior capsulotomy or both have given some gratifying results, and some older conditions come to arthrodesis.

Tuberculosis

Tuberculosis is much more common in Great Britain than in North America and presents to the British medical authorities a major problem in hospitalization and care. In fact, more stringent public health measures to control the dissemination of tuberculosis would seem to be in order. Every orthopaedic centre carried a heavy burden of these patients and many open-air hospitals were available exclusively to tuberculosis.

Great stress is laid upon constitutional therapy, rest, good food and fresh air. An ample supply of the latter is guaranteed in all weather conditions by the design of the wards and the response of both patient and physician to this treatment is most enthusiastic.

Simultaneously the local lesion is splinted. Joints are protected against weight-bearing and all but a minimal amount of motion. Most children with involvement of the vertebrae or lower limbs are nursed on a Jones abduction frame or on one of its many modifications. Plaster beds are more favored in adult work. These are beautifully made, and special turning devices and counterbalancing methods minimize the arduous task of nursing.

Attention was called to several cases of premature fusion of the epiphyses about the knee joint in association with long-continued immobilization of a limb for disease of the hip joint. Renal calculi were not a problem.

When the local and general reactions are favorable the indications for operating upon the patient are reviewed. Fusion across the joint is done primarily to maintain stability and is accepted for the hip and knee with greater alacrity than for the spinal column. This is difficult to understand. A somewhat earlier fusion performed to immobilize the involved segment of the spinal column during the more active stages of the disease is not regarded as beneficial. The arguments against such a procedure are not convincing. In addition the period of conservative treatment prior to fusion seems unduly long.

British surgeons have developed a rational method of treating Pott's paraplegia; timely interference by lateral decompression should be more thoroughly understood at home. While some fatalities have resulted from tuberculous meningitis, this is not an overpowering risk in the face of such a dread disease. The relief obtained in a majority of cases was most impressive. The supply of streptomycin is too small for any extensive experience in its use.

Scoliosis

Our contact with the problem of scoliosis was casual. No large, well-organized clinics for the care and treatment of these patients were in evidence though such organizations are forthcoming. There is a great opportunity for leadership in this field.

Equalization of Leg Lengths

The problem of equalizing discrepancies in leg lengths was discussed in some detail at two centres. Leg lengthening, usually of the tibia, was chosen as the surgical procedure to achieve this equalization. Both centers presented large series of cases demonstrating excellent surgical technic as revealed by the attainment of good length and bony union. There were, however, complications such as transient nerve palsies, valgus deformities of the ankle and limited motion of the knee. Leg shortening was performed only occasionally. It is our impression after observation of their results that leg lengthening should not be totally discarded; it may be used in instances in which considerable inequality is present and attack on the sound extremity alone would not accomplish sufficient improvement.

We were surprised that epiphysial arrest was so seldom considered. This method has proved its value in America. The surgical risk is minimal, and prolonged hospitalization and disability are reduced. We believe that the objection to interfering with the normal extremity and the decrease of stature has been overemphasized in Britain.

Surgical Treatment of the Painful Hip

The attention devoted to the surgical treatment of painful hips (malum coxae senilis, traumatic arthritis, old slipped epiphysis and so forth) was evidenced by organized discussions of the problem in more than half the centers visited. The surgical procedures in common use were arthrodesis, osteotomy, excision of the head and neck of the femur and cup arthroplasty. Indications for each were not always clear and the choice seemed to rest with the preference of the individual surgeon. Representative patients treated by the various procedures were shown to us and on the basis of our observations we formed fairly definite impressions.

Arthrodesis of the hip was the most favored operation. This favored position was based on the high percentage of painless stable hips. However, bony ankylosis was not always obtained and many patients had residual limitation of knee motion from plaster immobilization. In each clinic where arthrodesis was advocated, technical modifications were presented to produce fusion more certainly and to get away from plaster immobilization. A future study of end-results must yet tell us whether any technic to date will allow earlier ambulation and obviate plaster casts.

Subtrochanteric osteotomy of the femur had a very wide appeal in the treatment of painful hips We saw the results of the McMurray type more frequently than any other and the results varied widely, in general the pain was relieved at least in part and the range of residual motion diminished in proportion to the number of years after operation Some surgeons preferred what was termed a controlled osteotomy The operation was applied to realign the extremity in cases in which a painless range of motion existed if the hip was tested in the position of deformity Internal fixation was used to avoid plaster immobilization The results observed in this limited group were impressive, and the hip joints were functionally good as long as eight years after operation One distinct drawback existed—that of non union at the site of osteotomy Several such cases were shown us and, with bridges burned it was difficult to suggest further treatment

Excision of the head and neck of the femur for the treatment of a painful hip was carefully presented to us in several centers Since this was not a common procedure in America, we were extremely interested in seeing end results It was encouraging to note the amount of stability and the range of painless motion that was accomplished by surgical excision of the joint The stability was enhanced on many occasions by the use of a trochanteric osteotomy allowing the trochanter to parallel the direction of the acetabulum An insufficient number of such cases was seen to allow us to form any firm convictions but it does seem well established that such a procedure is possible and justifiable provided one does not hesitate to sacrifice a small amount of stability in order to gain a fair range of painless motion

Mold arthroplasty of the hip has gained many supporters since it was taken up at the end of the war It was impossible to judge the results except in single isolated instances but the results were sufficiently good to warrant acceptance of the growing demand for a movable hip There were many minor modifications of technic from the original described by Dr Smith-Petersen By and large, the best results shown us were in those cases in which a very large medially placed acetabulum had been made and a sufficiently large freely movable mold had been applied

It is obvious that the surgical treatment of the painful hip is far from standardized This is just as true at home as it is abroad There is a great need for evaluation of the surgical treatment of painful hips With such a standard it would be possible to compare the results of one type of operation with another and in the future establish more definite indications for each type of operation

Trauma

When the methods commonly employed in the management of fractures in Britain were compared with those in America no essential differences were observed Discussions within our group failed to sustain the oft-expressed impression that open reduction was less frequently the choice of treatment with our British colleagues As in the United States and Canada only a few centers in Great Britain practised strict non touch surgical technic It became evident during the tour that individual practice varied as much on one side of the Atlantic as on the other While no radical new concepts of treatment were observed many interesting solutions to fracture problems were encountered In many centers the emphasis is on early function and minimal immobilization

At several hospitals series of fractures of the os calcis had been treated by open operation following the method described by Ivor Palmer The early results did not show any increase in the range of motion of the foot as compared with patients treated by conservative means and the period of disability was not shortened the appearance of the foot however, was almost normal Observations on the late results in these cases will be of further interest The more frequently observed treatment was that of early mobilization without any attempt at reduction

Simple compression fractures of the spinal column are most commonly treated as we treat them with reduction and immobilization in a position of hyperextension However, in some of the mining districts where these injuries are very common compression up to one-third of the height of the vertebral body is not reduced or immobilized Active exercise and intensive reconditioning of the musculature of the back are prescribed at an early date By this method the period of disability was said to be reduced

Fractures of the femoral shaft were almost universally treated by traction A few cases of intramedullary fixation by a Kuntscher nail were shown Early exercise and joint motion are encouraged Fractures of the femoral neck are almost universally treated by internal fixation with a three-flange nail In some centers intertrochanteric fractures are fixed with a blade plate and in others traction is used There is not the economic factor necessitating early ambulation and discharge from the hospital because most of these elderly patients cannot go home until their fractures are healed

Accident centers are well organized to provide excellent care At one institution emphasis was placed on training younger men equally well in plastic surgery general surgery neurosurgery and the handling of fractures that is they were trained to be rather good at all but not superlative at any This approach, however has many advantages

The treatment of burns was carried out with an elaborate routine The end-results were quite convincing that this detail paid off admirably

Recurrent dislocation of the shoulder is a favored subject in Britain, and well it might be We saw several demonstrations of the pathologic aspects of this condition and the two most popular technics to its repair the Bankart operation and the Putti-Platt technic The British were almost adamant in th adherence to these technics, perhaps they re right

Hand Surgery—Peripheral Nerve Surgery

Surgical treatment of the hand is generally very well carried out, and some of the work we were shown was indeed superb The best work was done in those centers where the patients with abnormal conditions of the hand were segregated under the care of an interested surgeon, or team, equipped to deal with all the tissues of the part The treatment of crippled hands involves peripheral nerves and skin, as well as bones, joints and tendons, and the artificiality of tissue specialization is well demonstrated in this small but vital part where such varied anatomic structures are contained in so small an area that injury or disease does not confine itself to one type of tissue Surgery of the hand is obviously a field which demands special knowledge and technic and the surgeon who enters the field only occasionally and without adequate preparation must accept mediocre results in Britain as well as in America

We were particularly impressed by the excellent work being done by a number of British orthopaedic surgeons on peripheral nerve injuries In one center, we saw late results of nerve sutures and nerve grafts that were superior to any we had ever seen anywhere In several hospitals, we were shown splendid examples of free and pedicle skin grafts applied to the extremities We were impressed by the fact that orthopaedic and plastic surgeons often belong to the same societies and attend common meetings Because of the frequency of combined skin nerve, and osseous lesions of the extremities as well as of the hands the impracticality in many instances of having a specialist for each tissue is obvious We were much impressed by the desirability of giving the orthopaedic trainee more experience in plastic surgery of the extremity and in peripheral nerve surgery

Rehabilitation

Sir Robert Jones' doctrine that orthopaedic care should consist of prevention, treatment and job training has made an indelible impression upon the rehabilitation centers which were visited Well organized programs associated with hospitals government and industry are producing results which justify a close study of the method employed Four principal programs are offered residential training school on-the-job industrial rehabilitation centers, rehabilitation centers for coal miners and rehabilitation center for amputees

In the residential training schools, training is based on real production The instructors are tradesm and their aim is to produce a tradesman The work selected is work which cannot be mass produc such as boat-making tailoring brace-making upholstery and so forth Of interest is the experience w cerebral palsy patients who are assigned to simple upholstery work and mattress making Skill developed and confidence is acquired, and the individual is completely happy in this simplification of work The aim is to persuade the disabled that he can overcome his handicap Here is a program normalizing the disabled person Many of these individuals have been crippled all their lives so on the job training is not applicable Trainees are taken if there is a fair prospect that a reasonable standard of economic stability can be attained

On-the-job training is stimulated by a rehabilitation team consisting of an orthopaedic surgeon a plastic surgeon a rehabilitation superintendent and his deputy and an industrial physiotherapist The work is centered on a retraining shop run on standard production lines Repetitive exercises as a mean of restoring muscle power range of motion and active circulation are obtained in the retraining shop b adding special equipment to operating levers of a machine tool The special adapters used are the product of consultation between surgeon, engineer and patient

Spectacular results of this type of rehabilitation are found in the excellent functional result obtained the reduction of time lost from work absence of psychoneurosis and improvement of industrial relation between management and labor

Such an elaborate rehabilitation is permissible only in a large industry However, a similar plan f smaller factories has worked out very successfully where several smaller industries combined to contrib money equipment and material for fabrication

The centers for the rehabilitation of coal miners are seeking to reinstate the patient in the commu at the highest possible level A system of remedial exercises occupational therapy recreational thera and social service has greatly increased the percentage of patients returning to useful work in the min These centers provide a magnificent opportunity to study the correct after-treatment of various injury It follows, therefore, that the clinical research reports based on these cases should be looked for and and studied with interest

A rehabilitation center for amputees manifested an admirable co-operation between the ortho surgeon, the limb-fitting surgeon and the limb maker This team insured the patient a suitabl prosthesis and training in its use

Amputations

The surgical technics employed in major amputations of the extremities in Great Britain do not differ markedly from those employed in America, and the sites of election for amputation are similar to those employed here The same criticisms of the Syme s amputation and of disarticulations are encountered in England as in the United States

In contrast to the similarity of surgical procedures in amputations, there is a pronounced dissimilarity in prosthetic appliances furnished to the amputee The procedures followed in the provision of artificial limbs to amputees in Great Britain are unique In accordance with the trend to achieve complete nationalization of all industry, the design, manufacture and fitting of artificial limbs are centralized One company has a monopoly on the construction of artificial legs and another controls the manufacture of arms and hands The emphasis is on inexpensive, wholesale production which dictates the selection of materials that lend themselves to mass production Metal is used almost exclusively for artificial legs The inevitable result of mass production is standardization which is a definite disadvantage from the standpoint of the individual amputee Mass production of legs in metal does not permit the delicacy of fitting so necessary in a socket The cumbersome shoulder harness and the type of single axis knee, generally with a spring arrangement cause poor walking and an awkward gait

It is interesting to note that Great Britain along with most of the other countries of Europe does not furnish hooks for the arm amputees While it is agreed that the split hook is the most useful type of arm prosthesis, its appearance is frowned upon Therefore, in general, the arm amputee is furnished with a plastic hand with immovable fingers and a passively adjustable thumb This is affixed to the stump through the use of a plastic or a metal and-leather socket The artificial hand is essentially a dress hand and not one designed for utility For workers the hand is removed and a series of tools may be affixed to the socket through a ' quick disconnect There is a great variety of tools designed and furnished to the amputee These consist of special knives, forks, spoons hammers screwdrivers holders for various working tools and special appliances for typewriting drafting and personal care These tools are intended to be placed conveniently in the home and in the workshop and, therefore, are quickly available to the amputee when he desires to use them This solution to the problem of the arm amputee is in contrast to the one attempted in America where it is believed that a well-designed functional hook used with dexterity will permit the amputee to carry out most of the above mentioned functions without constantly changing the tools on his prosthesis

Postscript

We are now settled down in the States and in Canada in the complacent rut of routine practice—a haven of rest by comparison with the visit to Britain A kaleidoscopic array of events flits across our memories the skirling bagpipes haggis, the Gay Gordon the wood choppers and fire fighters Windsor Castle the Rolls Royce factory Rugby matches charming hostesses tartan waistcoats gin and sherry Oxford Street rare old books cathedrals mellow with age the beautiful green countryside—the list could go on and on

How can we ever repay our British friends for a trip that's an epoch in our lives? We saw a little bit of bad in the best of it and a lot of good in the worst of it and with American verve enjoyed and were impressed by all of it A toast to our orthopaedic associations and to all of our British friends who were so kind and courteous to a group of intemperate travelers!

CANADA

CANADIAN ORTHOPAEDIC ASSOCIATION—ANNUAL MEETING, 1949

The fifth annual meeting of the Canadian Orthopaedic Association was held at Devil s Gap Lodge, Kenora Ontario June 8–12, 1949

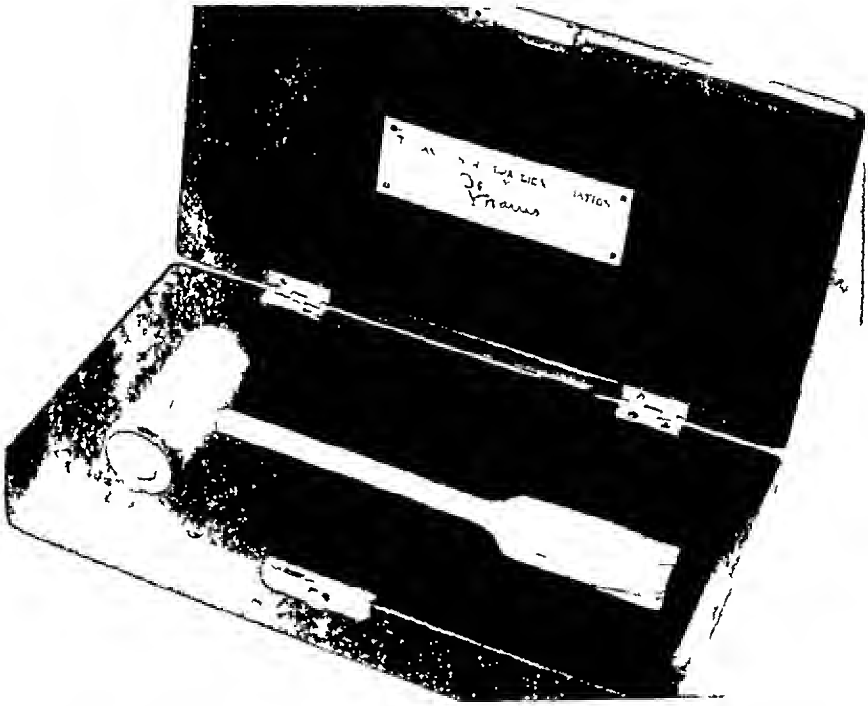
Presentation of a presidential gavel—At the annual dinner of the Association on the evening of June 10 the President *Dr R I Harris* presented a gavel for the conduct of meetings Dr Harris said that it had always been his wish that such a gavel should be made of distinctively Canadian material It had been made from the ivory of a narwhal tusk secured by Eskimo hunters in the Canadian Arctic through the facilities of the Hudson s Bay Company— ' The Company of Gentlemen Adventurers Trading into Hudson's Bay—Incorporated 1670 The case was made of Canadian walnut and the inscription plates were of Canadian silver The gavel was made from original narwhal tusk by the skilful craftsmanship of Dr C H Robson chief anaesthetist at the Hospital for Sick Children Toronto a man well versed in the peculiarities of orthopaedic surgeons '

Design for Coat of Arms of the Canadian Orthopaedic Association—*Dr Alexander Gibson* presented a design for the Coat of Arms and Seal of the Association for which provision exists in the Act of Incorporation The design emphasizes the nature of the specialty of orthopaedic surgery and the dual nationality, French and English, from which Canadians stem

Legg-Perthes' disease—*Dr R Gordon Townsend* (Calgary Alberta) reviewing the patholo... and treatment of Perthes' disease of the hip joint, referred to the findings of Howorth in fifty patients treated by operation Among thirty-three patients treated conservatively and followed up for a period of te... years only 12 per cent had a poor result

Late results in congenital dislocation of the hip—*Dr H A Gardiner* (Winnipeg, Manitoba) from the tremendous wealth of his accumulated material demonstrated many of the problems of congenital dislocation He emphasized the importance of early diagnosis, and said that although the shelf operation was useful in late cases with slanting acetabular margins old unreduced dislocations were often best left alone *Dr Smith-Petersen* (Boston) deprecated osteotomy in these cases because it increased the difficulty of performing mould arthroplasty in later years

Slipped upper femoral epiphysis—*Dr Alexander Gibson* (Winnipeg, Manitoba) said that the treatment o... slipped upper femoral epiphysis by manipulation should be reserved for cases of acute slipping even the... it should be used only with caution Open operation was indicated in subacute cases when there was moderate or severe slipping The danger of pseudarthrosis at the site of osteotomy had to be considered



Gavel constructed from the ivory of a narwhal tusk obtained from Eskimo hunters in the Canadian Arctic, with a case of Canadian walnut and inscription plates of Canadian silver presented to the Canadian Orthopaedic Association by its President, Dr R I Harris

Mould arthroplasty of the hip joint—*Dr M H Smith-Petersen* (Boston Mass), guest speaker, reviewed arthroplasty of the hip joint from its early evolution in 1923, and gave a detailed description of approach to the hip joint and the technique of joint reconstruction Three important difficulties experienced in former years had now been overcome poor exposure, poor instruments and a poor barrier between th... articulating surfaces fascia having been replaced by a vitallium cup All stages of post operative c... were illustrated The results of 700 cases operated on over a period of ten years were reviewed Th... author chose to avoid the term end-results because a ten-year follow-up was not long enough to justify the use of this term

Denervation of the hip joint for hypertrophic arthritis—*Dr J L Larochelle* (Quebec) repo... observations on the innervation of the hip joint based on dissections of 106 subjects Nerve fibr... came from the obturator nerve and the nerve to the quadratus femoris In sixteen subjects there ... no articular filaments from the nerve to the quadratus femoris there was an accessory obturator ne... supply in five Indications for denervation of the joint were Little's disease, chronic arthritis witho... deformity of the femoral head, arthritis when extensive surgery was refused arthritis when the gene... condition prohibited major surgery bilateral coxalgia and 'painful adductor sprain Neurecto... might also be advisable when pain persisted after arthroplasty

Synovectomy in chronic arthritis of the knee joint—*Dr J Edouard Samson* (Montreal ... traced the historical development of synovectomy of the knee Between 1930 and 1946 one hundr...

ninety-two patients had been operated upon with good results in 40 per cent. Patients with severe flexion contracture, and those with disabling polyarthritis, were not considered suitable. The complications included haemarthrosis, wound infection, severe post-operative joint stiffness and myositis ossificans.

Errors in the diagnosis of internal derangement of the knee joint—*Dr H H Boucher* (Vancouver, B.C.) reported one hundred and seventy-five derangements of the knee joint seen at the Shaughnessy Hospital, Vancouver, with an error in diagnosis of 12.5 per cent., and eighty cases seen in private practice with a 9 per cent. error. The main factor in reducing the percentage error in diagnosis was appreciation of McMurray's diagnostic manoeuvre. Hypermobility of the meniscus was an important cause of derangement. Errors in diagnosis included early tuberculosis of the knee joint and chondromalacia of the patella. There was sometimes error in attributing the lesion to the wrong meniscus, and in others the knee joint was normal.

Diagnosis of difficult vertebral lesions by trephine biopsy—*Dr John C Kennedy* (London, Ontario) demonstrated the technique of trephine biopsy based upon the use of an instrument devised by Dr Harris. The technique was similar to that used for paravertebral block. Radiographic control and general anaesthesia were used. Six cases were presented with photomicrographs. The method had been used in the diagnosis of many patients treated at the Hospital for Tuberculosis, Weston, Ontario, and at the Toronto General Hospital.

Femoral torsion as a cause of in-toeing and out-toeing—*Dr W T Mustard* (Toronto, Ontario) said that abnormality of gait with in-toeing or out-toeing might be due to forefoot adduction or internal tibial torsion, but it was necessary also to look above the level of the knee joint; femoral torsion was a common cause. Delay in rotation of the limb at the upper end of the femur led to torsion and anteversion of the femoral neck so that the limb must be rotated inwards to maintain the head in the acetabulum. In mild cases treatment by holding the limb in external rotation in Denis Browne night splints was satisfactory, but supracondylar rotation osteotomy was sometimes necessary.

Treatment of bone tuberculosis in North American Indians and Eskimos—*Dr J Olaf Rostrup* (Edmonton, Alberta) reviewed the treatment of bone tuberculosis in Indians and Eskimos over a three-year period from 1946–49. Seventy-three patients had been treated, but many others who were unfit to travel had probably died without treatment. Most were young; only 5 per cent. were over the age of forty years. Conservative treatment had been used. Streptomycin had been reserved as a lifesaving measure and as an adjunct in treating sinus tracts.

Conservative treatment of brachial neuralgia—*Dr G H Ryan* (Winnipeg, Manitoba) discussed brachial neuralgia in a series of patients including 169 men and 199 women. Neuralgia occurred usually in the 50–60 year age-group. The syndrome was characterised by pain in the neck and shoulder radiating to the deltoid insertion or to the base of the occiput. Protrusion of cervical intervertebral discs or hypertrophic arthritis of the intervertebral joints was often responsible. In 303 of the 368 cases conservative treatment by head traction for a period of ten days to three weeks, with massage and ultraviolet radiation, relieved the symptoms.

Congenital hallux varus—*Dr A W Farmer* (Toronto, Ontario) discussed the unusual problem of congenital hallux varus. This might occur alone, with metatarsus varus, or with congenital club foot. The great toe was sometimes at right-angles to the general axis of the foot, thus making it impossible to fit a shoe. Operative repair consisted of suturing together the great and second toes, using a skin flap from between them to fill in the region over the medial side of the first metatarso-phalangeal joint, which was opened to align the phalanx with the metatarsal.

Epidemic of poliomyelitis among Eskimos at Baker Lake—*Dr Duncan Croll* (Winnipeg, Manitoba) reported on his recent visit to Baker Lake in the Canadian Arctic to deal with an extensive epidemic of poliomyelitis. This was the first recorded occurrence of the disease in Eskimos. General interest in his report was enhanced by the excellent series of photographic colour transparencies which depicted the manner of life of the Caribou Eskimos and the environment in which they live.

Syme's amputation—*Dr W B McKinnon* (Winnipeg, Manitoba) in reporting twenty-seven Syme's amputations recalled that the operation had been devised originally for the treatment of tuberculosis of the tarsus or ankle. As indications he would include also certain injuries, vascular defects, foot deformities and infections. Four such amputations had been carried out for neurotrophic abnormalities.

Suction socket prosthesis—*Dr R C Rider* (Toronto, Ontario) outlined the history of development of the suction socket. A motion picture demonstrated the fitting and application of the prosthesis and displayed the gait of various patients. The prosthesis was unsuitable for patients with osteomyelitis, for those with deep infolding scars or serious skin eruptions, and for patients with poor psychological attitude. The real advantages were the elimination of a pelvic band and harness, and the excellent gait which was usually acquired.

Intramedullary nailing of fractures—*Dr Antonian Samson* (Montreal, Quebec) reported results from an experimental study of intramedullary fixation of fractures in rabbits, and reviewed seven years' experience of the treatment of fractures by intramedullary fixation in human beings. From this accurate

and detailed study he concluded that intramedullary nailing should always be preceded by open red[illegible] the nail must be of the correct size the femur was the ideal bone for this treatment, intramedullary [illegible] of the clavicle humerus and tibia should be abandoned

Traumatic arterial spasm—*Dr Ian W Davidson* (Sudbury, Ontario) reviewed the problems of traum[illegible] arterial spasm and ischaemia of limbs due to direct or indirect injury to the nervous control of the art[illegible] supply He classified the clinical types and outlined the treatment of all stages in detail

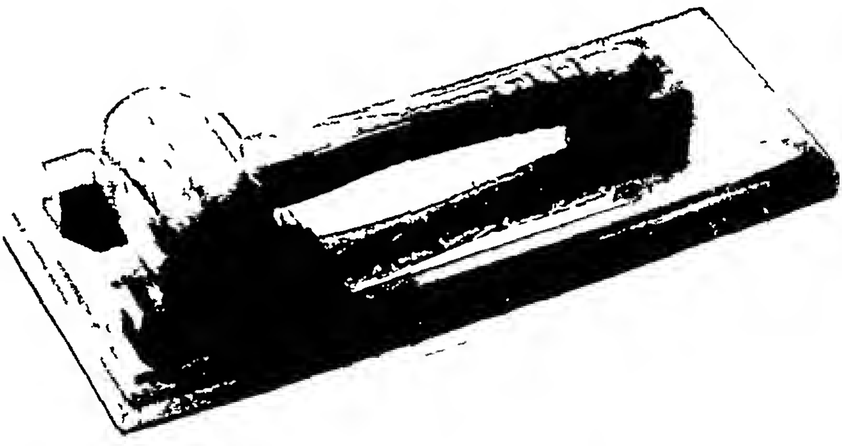
Sympathectomy in the treatment of peripheral vascular disease—*Dr Gordon M Dal[illegible]* (Toronto Ontario) reported one hundred ganglionectomies performed in eighty patients with vascular disease over a twenty-year period Unusual complications of Buerger's disease included two cases of rupture of the myocardium two of atrophy of the testicle and many of mesenteric thrombosis All these complications occurred in young people Paravertebral block was not a good indication of the value of sympathectomy In reviewing the results of treatment the importance of early operation was stressed

Fat embolism—*Dr E S James* (Winnipeg Manitoba) presented two cases of fat embolism Micro[illegible] examination revealed fat in the lungs and kidneys The first patient presented a classical radiograph picture of fat embolism of the lung despite early hemiplegia he recovered The other patient died

Clinical demonstration at Winnipeg—On the last day the meeting was transferred to Winnipeg in *order to observe demonstrations of the postero-lateral approach to the hip joint practised by Dr [illegible]* At the Department of Veterans Affairs Deer Lodge Hospital, the technique was demonstrated in anatomical specimens and also in many patients in whom the approach had been used for arthroplasty of the hip joint in osteoarthritis

AUSTRALASIA

New Zealand—The annual meeting of the New Zealand fellows of the Royal Australasian College of Surgeons was held in Auckland on Thursday and Friday, August 25–26 1949 The clinical programme included a report of three cases of excision of malignant tumours of the maxilla by Mr Webster with a discussion on plastic repair by Mr Brownlee Mr Leslie Will discussed osteoid osteoma Mr Chri[illegible] gave a report on autogenous bone grafting Mr FitzGerald discussed hallux valgus The surgery of tendons was the subject of a report by Mr Pike



Gavel presented to the Australian Orthopaedic Association by orthopaedic surgeons of the Royal Navy

Australian Orthopaedic Association—The report in this number of the Journal of the presentation of a gavel to the Canadian Orthopaedic Association by its President Dr R I Harris reminds us that a[illegible] gavel was presented to the Australian Orthopaedic Association by the surgeons of the British Navy were serving in Australia during the recent war We take the opportunity of reproducing a photo[illegible] of this instrument of office which includes on its silver plate the inscription

A O A 1945

This Presidential Mallet made of Australian woods in the Red Cross Remedial Workshop of the Royal Naval Hospital Sydney is presented to the Australian Orthopaedic Association as a very small memento of the Association's kind hospitality to Medical Officers of the Hospital

together with the signatures of H Jackson Burrows O Vaughan-Jackson *James Wishart* R[illegible] D R Maitland J F R Withycombe and H P Watson

GREAT BRITAIN

BRITISH ORTHOPAEDIC ASSOCIATION—ANNUAL MEETING, 1949

The annual meeting of the British Orthopaedic Association was held at Bristol in October 1949 under the presidency of Mr S A S Malkin Among the many visitors were Dr J Agerholm Christensen of Copenhagen Mr L P Fouche of South Africa and Professor J Verbrugge of Antwerp A clinical demonstration at the Winford Orthopaedic Hospital by Mr Pridie Mr Eyre Brook and their associates paid tribute to the inspiration of Hey Groves whose spirit still lives

DISCUSSION BY FELLOWS OF THE ASSOCIATION ON THE RELATIONSHIP OF ORTHOPAEDIC SURGERY TO TRAUMATIC SURGERY

Mr William Gissane (Birmingham) said that many young surgeons had been admitted to membership of the Association without full training in orthopaedic surgery and solely on their experience of emergency surgery in the treatment of bone and joint injuries A discussion on the relationship of accident surgery to orthopaedic surgery and the training of surgeons who would practise traumatic surgery was urgently needed In the earlier part of the century orthopaedic surgeons had laid claim to the surgery of the locomotor system and had specifically included the treatment of accidents, but even now in the middle of the century this commitment had not yet been accepted fully Many patients were still referred to orthopaedic departments after long delay in hospital casualty departments so that orthopaedics remained only the second line of treatment and gained little opportunity of advancing the early treatment of open wounds burns and hand injuries The same point had been reached in the development of plastic surgery, again there was the first barrier of a casualty department which was not always staffed sufficiently and often caused unfortunate delay It was now to be considered how to make a practical reality of the best possible treatment of injuries at the acute stage Quite surely this was not to be achieved by the development of yet another speciality segregated and confined within the limits of the term accident surgeon

No less than 80 per cent of patients were admitted to casualty departments by reason of accident In 10 per cent there were infections of the skin and subcutaneous tissues and only 10 per cent called for reference to the medical or general surgical departments In a single year one and a quarter million accident cases were treated in the casualty departments of 1,318 hospitals in this country and the vast majority were injuries to the locomotor system Of injuries to the head chest and abdomen less than half called for surgical intervention It could be claimed justly that control of the casualty departments of these hospitals was part of the commitment of orthopaedic surgeons

The establishment of fracture clinics as recommended by the Delevingne Committee did not comprehend the problem The treatment of fractures was but a small part of the work of accident services The Birmingham experiment with facility for the reception immediate treatment and after care of patients with every form of injury, had proved successful A comprehensive service for a population of approximately two million people could be developed on these lines Simple accidents might still be treated in the casualty departments of their local hospitals but when the injury was of a specialised nature or when it was serious, the patient should be transferred at once to the central accident hospital where on both economic and clinical grounds, it was reasonable to create full facilities and have the essential skilled staff available every hour of the day and night After-care and out-patient treatment could still be undertaken at the peripheral hospital nearest to the patient s home

The accident unit must not become segregated it should develop a relationship with surgery as a whole and maintain an association with orthopaedic and plastic surgery To cover the treatment of accidents in this country approximately twenty units similar to the Birmingham Accident Hospital would be needed but every such unit should be attached to the general hospital of a teaching school

The traumatic service should be controlled by orthopaedic surgeons In the Birmingham Accident Hospital surgeons with orthopaedic training had proved much more successful than those with general surgical training alone Orthopaedic training gave familiarity with the surgery of the locomotor system and the essential preliminary planning and after-care that was necessary At the same time there was need for acceleration in speed of thinking and decision when orthopaedic surgeons were faced with the problems of acute injury Moreover it was absolutely essential to plan additional training in the technique of plastic surgery

There had been neglect in the instruction of young graduate house officers in such fundamentals as the care of the open wound, the after-care of diseases and injuries of the locomotor system and the planning of treatment with a sense of time and cost in relation to the work of the patient After preliminary training in general surgery and full training in orthopaedic surgery, surgeons who proposed to specialise in accident surgery should learn at least the first principles of plastic surgery and thereafter gain practical experience of the work of a special unit such as that in Birmingham There might one day be a degree in orthopaedic surgery which would include a knowledge of accident surgery no less real than that now accepted in the surgery of congenital and established deformities

Mr E A Nicoll (Mansfield) said that traumatology was now practised in Great Britain in three ways: in conjunction with orthopaedics, as a part of general surgery and as a specialty in its own right. It was to be considered whether traumatology had yet earned the right to be regarded as a specialty. Certainly there was much more than the treatment of fractures, injuries to every part of the body were included, and there was in this field of surgery a wider repertoire of technique than in most special branches. But there were two difficulties in accepting traumatology as a specialty. It dealt with acute conditions, which limited the geographical area to be served effectively by any one team, only in a few large and densely populated industrial areas would it be possible to collect the variety of material necessary to keep a first-class unit at full stretch. Moreover, if all accident cases in a given area were to be dealt with by a traumatic specialist, cold orthopaedics would become self-contained—which would be unfortunate. Traumatology should be practised as a specialty only in exceptional circumstances. Even then the traumatic specialist must always have been experienced in orthopaedic surgery. For the most part it was undoubted that traumatology should be combined with the ordinary practice of orthopaedics, the orthopaedic surgeon first being trained in certain additional techniques and taught the art of quick decision. The real solution lay in a better distribution of orthopaedic surgeons throughout the country. Only when this had been achieved could traumatology be separated from the practice of general surgery and from that of general practitioners "with a flair".

Mr H Osmond-Clarke (London) asked three questions. Where was the accident service to be located? Who was to treat the accident cases? What should be the training of the accident surgeon? Accident hospitals had achieved success, but the accident unit should usually be sited in a general hospital. Close contact with teaching hospitals must be achieved. Whether or not the surgeon confined himself to the treatment of traumatic cases he must have had preliminary training and experience in orthopaedic surgery. It was true, as Mr Nicoll had pointed out, that reliance must sometimes be placed on general surgeons, but in these cases the patient should be transferred as soon as possible to the nearest well organised accident unit. Both Mr Gissane and Mr Nicoll had agreed that the training of accident surgeons should include general surgery, general orthopaedic surgery and the special techniques required in the treatment of shock, burns and the replacement of skin loss. He visualised that orthopaedics might become divided into separate specialties for the treatment of arthritis, congenital deformities, injuries, and other groups of cases, but wondered whether the practice of any one subdivision such as accident surgery would be enough to satisfy a man who was trained fully in orthopaedics.

Mr Rainsford Mowlem (London) said that the Association must consider whether the orthopaedic surgeon was in fact the best man to be a traumatic surgeon. The integrity of skin was of prime importance in the treatment of all locomotor tissue injuries. Skin restoration must often precede orthopaedic measures. He hoped that there would always be full co-operation in any traumatic unit between the plastic surgeon and the orthopaedic surgeon.

Mr Philip Wiles (London) asked how the training of an orthopaedic surgeon was to be determined. Specialists in general surgery were labelled by the possession of a Fellowship. In orthopaedic surgery there was usually no special examination or degree. Should there be a more organised system of training with a University degree in orthopaedics?

Mr R H Metcalfe (Purley) said that traumatic surgery had gained great emphasis since the last war but the training of young orthopaedic surgeons had presented some difficulties. In one Metropolitan region a special scheme had made it possible for registrars to gain experience in several different orthopaedic units. In each area, six orthopaedic registrars had alternated appointments in the casualty departments of major hospitals, in the wards and consultative out-patient departments of general hospitals, and in the long-stay orthopaedic hospitals. Such wide experience was invaluable, but the problems of organisation were not simple.

Mr Bryan McFarland (Liverpool) said that it would be most unfortunate to set up an "Institute of Traumatology" as a separate branch of surgery. The accident unit should be within a general hospital with an orthopaedic surgeon in charge. Those training in orthopaedic surgery should gain experience in trauma as part of their training. The plastic surgeon should co-operate both in the treatment of injury and in the training of orthopaedic specialists. The planning of a University degree in orthopaedic surgery was complicated, but the difficulties could be met if teaching was more closely organised and if the degree was awarded only after a period of approved experience.

Mr H A Brittain (Norwich) advocated the establishment of a certifying board by the British Orthopaedic Association on the lines of the American Board of Orthopaedic Studies.

Mr N Birkett (Nottingham) considered that special accident hospitals were impracticable in many places. Practical experience of orthopaedics over a long period was far more important than the issue of a certificate.

Miss M Forrester-Brown (Bath) drew attention to the difficulties of transport in many areas where the population was dispersed and referred to the Ontario scheme by which radiographs of patients who had sustained fractures were sent over long distances to orthopaedic experts who then advised as to whether the position of the fracture should be accepted or whether further reduction was necessary.

The President while admitting the difficulties of transport, hoped sincerely that they would not be met in the manner described by Miss Forrester Brown as the "Ontario scheme"

Mr Norman Capener (Exeter) referred to the special problem of the wide dispersal of accident cases in agricultural districts Accident centres were very necessary but there had to be many of them They must always be in general hospitals of varying size The training of individuals for orthopaedic surgery and for traumatic surgery should be undertaken in general hospitals

Mr M Langston (Southampton) asked for an immediate and practical policy Large accident units for the treatment of patients and for the training of specialists were not yet in general existence It seemed to him that the area scheme by which registrars alternated between various types of unit as outlined by Mr Metcalfe was excellent

Mr Norman Roberts (Liverpool) believed that the accident hospital as described by Gissane, was not the right answer The accident unit should be sited in the general hospital Furthermore the casualty department of a general hospital should be under the control of the accident service and directed by the orthopaedic surgeon

Mr J Scott (Oxford) supported Mr Roberts view that accident work should be retained in general hospitals and not be directed to special accident hospitals In referring to the question as to whether or not there should be traumatic specialists, he said that the crux of the matter was whether or not orthopaedic surgery was yet too large a subject Theoretically it might be but in practice it was not There were several possible sub divisions of orthopaedic surgery but as to how it should be divided was not yet clear The necessity for comprehensive preliminary training in all sub divisions of surgery was undoubted and it could not be denied that many traumatic surgeons were inadequately trained in orthopaedics

Mr E N Wardle (Liverpool) deplored the tendency to appoint the most junior member of a general hospital staff to the accident or casualty department

Mr Roland Barnes (Glasgow) said that the formation of special accident hospitals would present very great difficulties in the training of undergraduates Every teaching hospital should have within its precincts an accident unit under the control of the orthopaedic department

Professor George Perkins (London) said that the discussion had been planned on broad lines It was necessary to determine the attitude of the British Orthopaedic Association to traumatology In summarising the discussion he suggested that three resolutions might be agreed namely 1) every man practising orthopaedic or traumatic surgery must be properly trained, 2) the Association must not be divided, 3) traumatology must not be encouraged as a specialty

The President in closing the discussion welcomed the clarifying views of Professor Perkins and endorsed his three points Mr Nicoll had made an admirable summary of the existing situation and the Association could not fail to agree Practical experience was of much greater importance than the possession of a special degree The emphasis must be on training in general orthopaedic surgery and thereafter special training in the principles of plastic surgery and specialisation in traumatology

LESIONS OF THE LUMBAR INTERVERTEBRAL DISCS

Mr J Pennybacker (Oxford) basing his remarks on 800 cases most of them with root pain referred to the importance of differentiating neoplasms such as neurofibroma ependymoma, meningioma and intramedullary tumour of the conus In such cases the patient might ascribe the onset of symptoms to a strain of the back and the symptoms might be intermittent but the neurological signs of muscle wasting altered cutaneous sensation or abnormal reflexes were usually progressive Radiographs often showed no change but they might reveal scalloping of the posterior surfaces of the vertebral bodies or increase of width between the pedicles Lumbar puncture usually revealed increase in the protein content of the cerebrospinal fluid and myelography established the diagnosis Tumours had been present in less than 5 per cent of his series Other conditions to be differentiated included tuberculous disease of the lumbar spine or sacro iliac joint metastatic carcinoma and spondylolisthesis In twenty-seven cases (rather more than 3 per cent) no lesion had been found Two signs were particularly useful Nafsigger s sign in which with the patient upright jugular compression caused paraesthesiae of root distribution ceasing when pressure was released—a sign which was positive in any root lesion and secondly sudden pressure over the lumbar spine of the prone patient which might cause local pain and reference to the sciatic distribution Treatment by bed rest a plaster jacket for six weeks and thereafter a corset, was advised Operation was reserved for cases that did not respond to such treatment and for those with frequent recurrence Manipulation was not favoured because it had caused almost complete lesions of the cauda equina which recovered slowly and might leave permanent loss of sphincter control Exploration should be extensive and include the fourth and fifth lumbar and first sacral roots The spinous processes and lower margins of the laminae of the corresponding vertebrae were removed Both sides were explored and the theca was opened Multiple lesions were unusual Arthrodesis was usually performed only at a secondary operation when relief was incomplete Occasionally in the second or third weeks of convalescence the patient suffered agonising spasms of pain in the back, precipitated by movement and without sciatic

irradiation, and in such cases the radiographs showed fuzziness of the adjacent vertebral bodies [illegible] subsequently a good deal of new bone formation Treatment of this complication in the acute stage was by immobilisation in a plaster bed for four or five weeks Such cases did well and he doubted whether they were due to infection

Mr E N McArdle (Liverpool) said that it was a mistake to concentrate attention upon one disc when there was loss of equilibrium of the whole lumbar spine with loss of elastic reaction of many discs In such a state retropulsion and sciatica were no more than incidental The orthopaedic principles of correction and fixation were met by the application of a plaster jacket in head suspension Of 269 patients treated between 1937 and 1949, 60 per cent had gained complete relief Relapse might occur and in these patients with permanent loss of elasticity of a disc operation might be necessary, but it should still be treated after operation by fixation external or internal

Mr J R Armstrong (London) dealt chiefly with the causes of operative failure In the first place there might be failure to find the lesion sometimes because there was none, but more often because of exposure at the wrong level or limited exposure at the correct level Mid-line protrusions were hard to find and ' concealed disc lesions were far more common than had been acknowledged Other causes of failure were failure to recognise a double lesion which occurred in about 20 per cent of cases failure to deal with a bilateral lesion which needed exposure on both sides insufficient removal of the disc which gave rise to further protrusion operative damage to the nerve root post-operative adhesion of the nerve root to the scar and especially to the remnants of nuclear material subsequent prolapse of a previously healthy disc permanent changes in the root from prolonged compression and arthritis of the intervertebral joint There were several reasons for not performing arthrodesis at the time of operation it was usually unnecessary the complications and dangers were greater, a longer period of post-operative immobilisation was required arthrodesis if necessary could be done more conveniently later, and it was difficult to do a second root operation after arthrodesis if the first operation had failed

Mr R H Young (London) discussed the result of operation in 832 cases in which it was considered that a pathological disc had been demonstrated He excluded an unstated number of cases in which no pathology was found or in which the pathology had no relation to the disc Whereas formerly he operated on about one-third of all the cases he saw, he said that he now operated on about one in fifty Nevertheless we understood from him that he performed 180 of these operations last year which would suggest unless we misinterpret him that he sees some nine thousand cases of lumbar intervertebral disc injury each year

Mr William J Virgin (Liverpool) in a paper read by Mr B L McFarland, recorded studies of deformation of vertebral discs under load, and recovery on release The elastic properties of the immature disc in childhood were less than in the adult Performance improved with successive loadings Incision of the annulus into the nucleus interfered little with the properties of the disc, which did not appear to depend upon an intact nucleus but upon the fluid content the disc losing water during compression and taking it up during recovery Elasticity diminished in wasting diseases and with local vertebral change

Mr G L Alexander (Bristol) discussed the coincidence of lumbar disc protrusion with spondylolisthesis A case of listhesis of the fourth lumbar vertebra on the fifth was associated with lumbo sacral disc lesion with symptoms referable to the first sacral root In seven cases of spondylolisthesis he had observed three with disc lesions at the corresponding or another level

Mr E A Nicoll (Mansfield) said that myelography with the newer radio opaque fluids was safe and was useful in determining the nature of the lesion and its level It might reveal a second lesion and give accurate conclusions

Dr E J Crisp (London) described the ruptured disc as a universal lesion having no age limit *He* [illegible] saw cases early and applied a plaster jacket without correction of deformity, which usually disappeared after a few weeks The plaster was changed at intervals but fixation was continued for ten or [illegible] weeks About 80 per cent of patients were relieved

Mr Sayle Creer (Manchester) advocated early operation *Mr Newman* (London) emphasized the dangers of flexion movement in manipulation *Mr Le Vay* (London) having operated on 130 patients was evidently less pressed than Mr Young this representing only 10 per cent of his series and *Mr K H Pridie* (Bristol) ascribed the low back tribulations of the twentieth century to the failure in modern times to observe [illegible] days rest in seven

Protrusion of cervical discs—*Mr G L Alexander* (Bristol) recalled that symptoms might be due to compression of a nerve root or compression of the spinal cord, and occasionally to both In the [illegible] of nerve root compression aching in the neck was often the first symptom and might be initiated by [illegible] Sensory manifestations were much more pronounced than motor changes but sometimes there was [illegible] power in the fingers The hyperaesthesia occasionally found over the upper part of the shoulder and [illegible] was perhaps due to intersegmental spread or vascular phenomena Muscle fasciculation [illegible] occurred and tendon reflexes might be modified It had been suggested that the almost invariable [illegible] of the roots of C 6 and 7 was due to proximity to a fixed part of the spine but he preferred to [illegible] the distribution to the thickness of the roots of C 6 7 and 8 the last root usually escaping [illegible]

course was less oblique and it was subjected to less traction by movements of the neck and shoulder. When operation was needed decompression was carried out with a dental drill. The syndrome of cord compression could occur from a ruptured disc anywhere from the second to the seventh cervical vertebrae. The higher ones might give bizarre sensory disturbances, confused distribution of muscle weakness and anomalous changes in the reflexes. The cervical vertebral canal was roomy so that compression of the cord was possible without change in the cerebrospinal fluid and lumbar puncture seldom helped. Disproportionate vascular disturbance sometimes produced a neurological picture suggesting an intramedullary lesion. Myelography with pantopaque or myodil was helpful. Cord compression called for laminectomy and removal of the displaced material. In both root and cord syndromes the results of operation were good but they were not perfect. *Mr Roland Barnes* (Glasgow) spoke of paraplegia in injuries of the cervical spine without bone displacement. In such cases the Queckenstedt test was unreliable. If myelography showed a disc lesion laminectomy should be performed.

Lambotte and the early period of bone suture—*Professor J. Verbrugge* (Antwerp) painted a vivid and charming picture of Monsieur Lambotte an early pioneer of bone suture who unlike his English counterpart Sir Arbuthnot Lane was still living at the age of eighty five. He still did two or three operations a month with a steady hand. A kindly witty highly cultured *bon viveur*, he was remarkably versatile and highly skilled. Among his hobbies were violin making and clock repairing.

Fractures of the upper end of the radius in children—*Mr C. C. Jeffrey* (Birmingham) had studied eighty fractures of the upper end of the radius in children and adolescents under the age of eighteen years treated during a six-year period at the Birmingham Accident Hospital. He limited his remarks to twenty-four cases of fracture through the neck of the radius or separation of the upper epiphysis. The cause of displacement was usually axial compression with abduction as shown by frequent association with avulsion of the medial epicondyle rupture of the medial ligament or abduction fracture of the ulna. The position of the forearm at the time of injury as to pronation or supination determined the direction of tilt of the radial head. This was estimated before reduction by radiography in various positions. With the forearm suitably rotated closed reduction was carried out by digital pressure on the radial head with the elbow adducted. Open operation was reserved for cases in which this manoeuvre failed or in which the head was completely displaced. In young children with twenty degrees of tilt or less no reduction was performed. Two cases in which the epiphysis was rotated through ninety degrees were believed to be due to momentary posterior dislocation with a blow on the back of the diaphysis in falling so that the epiphysis was displaced behind the humerus and left there at the recoil the displacement was reduced by operation. When there was tilting without separation late review at intervals up to six years showed that the results of manipulation and of operation were about the same there was no deformity some had slight restriction of movement and sometimes there was premature fusion of the epiphysis. Imperfections of reduction tended to disappear with growth. When there had been complete separation there was more often premature fusion deformity of the head and limitation of movement. *Mr R. C. Murray* (Inverness) believed that even if closed reduction failed open operation was seldom needed unless there was great displacement. Correction of the position took place as growth occurred. *Mr V. H. Ellis* (London) considered that limitation of rotation might be caused by subluxation of the lower radio ulnar joint from disproportionate growth of the forearm bones after premature fusion of the upper radial epiphysis. After manual reduction of a greenstick fracture of the neck of the radius the position could not be maintained because reduction of a greenstick fracture was unstable unless the fracture was completed. In this situation this was not possible. *Mr J. C. Scott* (Oxford) agreed that tilting in young children needed no reduction. [*Editor's note*—There is most certainly no general agreement with some of these observations. Uncorrected tilting of the head of the radius in children, even of lesser degree may cause not only limitation of radio-ulnar movement but limitation of extension of the elbow which does not change with growth however much the tilt may become masked in radiographs. When closed manipulation fails manipulation through a short incision is very easy—and despite theories about greenstick fractures it is always maintained.]

Experimental rupture of the medial ligament of the knee joint—*Mr E. A. Jack* (Edinburgh) had studied the changes after manual rupture of the medial collateral ligament by forced abduction of the knee in cats in which he had found the ligament to present a similar anatomical and vascular pattern to that of man. Rupture occurred at the upper end in seven, at or near the lower end in six and as an oblique involvement of most of the length of the ligament in six. Capsule and synovial membrane were involved in tears of the upper end and sometimes at other levels. Ligamentous recoil was invariable with a gap which could no longer be closed after seven to ten days. Healing occurred except in most cases of rupture at the upper end where failure might be due to the width of gap, ischaemia or leakage of synovial fluid. Animal experiments suggested that the best treatment of this ligament rupture was operative repair during the first week with the least possible interference with blood supply.

Hallux rigidus—*Mr A C Bingold* (Leeds) reported a radiographic and morbid anatomical study of hallux rigidus The dense and sometimes bipartite epiphysis for the base of the hallux which had been said to be a manifestation of osteochondritis juvenilis and a cause of hallux rigidus was no more than a normal phase of development from about the age of six years to adolescence The bony trabeculae threw a dense shadow in radiographs because they were at right angles to the axis of the digit Early hallux rigidus was characterised by synovial hyperaemic reaction effusion without evidence of infection and slight erosion of the articular cartilage of the phalanx but not of the metatarsal The anatomical changes of the osteoarthritis that developed were greater than radiographs would suggest *Mr Norman Roberts* (Liverpool) observed that the child with hallux rigidus often had stiffness of the corresponding thumb joint but *Mr K I Nissen* (London) referred to Harris and Joseph's observation that stiffness of this joint of the thumb was related to developmental flattening of the first metacarpal head and *Mr I ... Jack* (Edinburgh) had found that the stiffness of hallux rigidus in childhood disappeared under anaesthesia indicating that it was due to spasm

Osteotomy of the spine—*Mr H A Law* (London) showed a film of the operation and the dramatic results of osteotomy of the spine for deformity in ankylosing spondylitis The object was to produce a compensatory lumbar lordosis by making a gap in the neural arch and angulating the spine at this level by osteoclasis Not only was bone removed from the laminae and articular processes but the margins were so shaped that the fragments interlocked safely when the spine was extended Plaster of Paris was then applied to the trunk and thigh The operation had been performed successfully in seventeen cases

Experiences in Mauritius—*Mr J M Fitton* (Floreal Hospital, Mauritius) after a brief reference to the geography climate economy and races of Mauritius described the orthopaedic service that had been developed since 1945 when the island was stricken with an epidemic of poliomyelitis *Mr H J Seddon* (London) referred to the difficulty and magnitude of the task which Mr Fitton had so modestly described and the fact that this individual work had often to take second place to more pressing communal medical needs Colonial orthopaedic centres had now been established also in Malta, Nairobi and Lagos It was imperative that the men who undertook this pioneer work should have the prospect of suitable places when they returned home

Radiology and histopathology of malignant bone tumours—*Dr A L Taylor* and *Dr P N Bean* ... (Bristol) summarised the records of the Bone Tumour Registry at Bristol Royal Infirmary Seventy two primary tumours of bone had been recorded They were classified as 1) related to bone tissue osteogenic sarcoma chondrosarcoma fibrosarcoma 2) arising within the marrow cavity, Ewings tumour reticulo sarcoma multiple myeloma *Dr R C Tudway* (Bristol) pleaded for the treatment of osteogenic sarcoma by deep X-ray alone He gave three uses for deep X-ray treatment of bone tumours pre operatively in all cases for amputation as the only treatment in specially selected cases especially in the upper limb and as a palliative dose in inoperable cases *Dr S Curwen* (London) gave the indications for deep X-ray treatment of osteoclastoma and gave the results of recent cases *Mr Roland Barnes* (Glasgow) favoured biopsy in all doubtful cases and considered it a safe procedure *Mr H E Harding* (London) agreed with the value and safety of biopsy and showed slides of cases of diagnostic difficulty He stressed the four main objects of treatment relief of pain relief of anxiety keeping the patient ambulant saving life *Mr K I Nissen* (London) stressed the importance of age in the diagnosis of Ewings tumour which seldom occurred after the age of seventeen years and osteoclastoma which was unusual before the age of twenty years

Posterior scapulo-humeral arthrodesis—*Mr H A Brittain* (Norwich) demonstrated this operation and gave the results in thirty patients nineteen operated on by himself, ten by Professor Mercer and one by Mr Nisbet In twenty-four of these cases there was bony fusion

Pregnancy and skeletal tuberculosis—*Mr M C Wilkinson* (Black Notley) described the effect of pregnancy in thirty-two patients with skeletal tuberculosis He concluded that none had been harmed by pregnancy and that some had shown an increased rate of healing *Mr F G St Clair Strange* (Canterbury) said that in no case of twenty-seven pregnancies in patients with sacro-iliac tuberculosis was there sign of reactivation He did not hesitate to let the patient go to full term

Arthroplasty of the hip joint—*Mr Charles Gray* (London) showed an excellent film to demonstrate cup-arthroplasty of the hip performed through a lateral approach with removal of the great trochanter *Mr K H Pridie* (Bristol) favoured an antero-lateral approach to the joint

Election of Fellows and Members—At the business meeting of the Association elections to fellowship and membership were made —

Corresponding Member—R Merle d Aubigne Paris

Fellows—H E Harding London P B Moroney Liverpool S M Thompson Grimsby

Associate Members—H G A Almond Liverpool J E Buck London L M Crooks Royal ... J K Elliott, Wellington N Z N G C Hendry Aberdeen S A Jenkins London T L Lawson ... M L Mason London N H Morgan Derby, R H Simpson Northampton

SCOTLAND

CONTRIBUTION OF EDINBURGH TO ORTHOPAEDIC SURGERY

Inaugural Lecture, George Harrison Law Chair of Orthopaedic Surgery, University of Edinburgh —*Professor Walter Mercer* in his inaugural lecture discussed "The Contribution of Edinburgh to Orthopaedic Surgery"* and traced the development of treatment of the sick and injured from the eighteenth century. He recalled the work of great men of the past whose labour had laid the foundations of orthopaedic surgery. The seventeenth and early eighteenth centuries had seen violence and mob rule in Scotland but with the last of the Stuarts law and order had been asserted and under more settled conditions orthopaedic surgery was born.

In 1720 Alexander Monro was appointed Professor of Anatomy in Edinburgh and his brilliant teaching attracted many students from England. He was one of the founders of the Royal Infirmary of Edinburgh where the medical school quickly gained a European reputation. He made Edinburgh's first notable contribution to orthopaedic surgery by his description of loose bodies in the knee joint and their origin from the cartilage of the articular surfaces. His *Anatomy of the Human Bones* went through eight editions in his lifetime. Robert Whytt, colleague of Monro and brilliant physiologist, who was appointed Professor of the Theory of Medicine in 1747, first localised the seat of reflex action in the spinal cord and showed that it was independent of the brain.

About the time of the Battle of Dettingen in 1743 Sir John Pringle, who was regarded as the founder of modern military surgery, made the historic suggestion that military hospitals of opposing armies should be regarded as neutral and immune from attack, a suggestion that was accepted by both sides and led eventually to the formation of the Red Cross Society. Pringle was a pioneer of antisepsis. In his paper entitled "Experiments upon Septic and Antiseptic Substances" the word *antiseptic* was used for the first time in history.

The next important name was that of Benjamin Bell, a medical student in 1766, who was a pioneer of physiotherapy and achieved regional anaesthesia by compression of the nerves supplying the part to be operated upon. At about the same time John Bell (1765–1820) made valuable contributions in the field of surgical anatomy and advised approximation of wound surfaces closely and evenly in contact so that they might adhere to each other, a method that was contrary to the usual practice at the time. James Russell (1755–1836), the first incumbent of the Chair of Surgery in Edinburgh, gave a detailed description of osteomyelitis, a disease which was imperfectly understood. Sir Charles Bell (1774–1842), who began his study of the nerves in Edinburgh before taking up practice in London, was the first to show that there were two kinds of nerves, sensory and motor, and his name is famous for his account of paralysis of the seventh cranial nerve and the long thoracic nerve. Later he returned to Edinburgh as Professor of Surgery.

At this time, in the first half of the nineteenth century, the surgical school of Edinburgh was at the height of its fame. Two figures stood out above all others—Liston and Syme, and orthopaedic surgery owed a debt to both. While in Edinburgh Robert Liston was a successful teacher of anatomy; Syme was his demonstrator. One of his earliest contributions to orthopaedic literature was on "Fractured Neck of the Femur." Although Liston's long splint was seldom used to-day it was he who first emphasized the necessity for efficient immobilisation of the fragments. Among other contributions were the flap method of amputation, the club foot shoe, devices for reducing dislocations, bone forceps, and an ingenious apparatus for the treatment of ruptures of the tendo Achillis. His description of this tendon injury was graphic: "It is an accident that most frequently occurs to those who have been for a time unaccustomed to violent action of the muscles. It happens to gentlemen of mature years, who, forgetting these, join in the sports of youth, attempting to skip and dance as they were wont to do, suddenly they suppose that someone has inflicted a blow on the leg from behind—their dancing is arrested, the foot cannot be extended and the nature of the case is forthwith apparent to the most careless observer." The painting of Liston now in University College, London, shows him performing the first operation under ether in Britain.

James Syme, born in 1799, having been denied an appointment at the Royal Infirmary, established his own private hospital in Edinburgh. His important contributions were on excision and amputation and the impressive plea that he made for excision of diseased joints as an alternative to amputation was a lasting contribution to conservative surgery. Syme's amputation of the foot, a subject of recurrent controversy, is still advised in Edinburgh as well as in Canada and the United States. Syme was the first in his country to perform subcutaneous tenotomy for torticollis and excision of the clavicle for sarcoma.

Another great name was John Goodsir, an anatomist of distinction who did valuable work on the formation of bone. In 1843 he claimed that bone was deposited and absorbed by living cells and not directly by the arteries and lymphatics themselves, as had been described. He made important observations on articular cartilage. It was about this time that Hugh Owen Thomas, "the father of

* *Published in full in the Edinburgh Medical Journal* (1949) 56, 173.

modern orthopaedic surgery, came to Edinburgh from Wales to study for his diploma He stayed two years and was described as "an honourable and industrious student of an enquiring mind and with a desire to know the truth

Coming to more recent times Professor Mercer mentioned the work of Thomas Annandale whom he met personally as a first-year student Annandale succeeded to the chair of clinical surgery in 1877 He made history by his operations on the knee joint reporting the removal of cartilaginous loose bodies by direct incision in 1879 and being the first to describe a deliberate and planned operation for the relief of internal derangement of the knee joint due to displacement of a cartilage Finally said Professor Mercer Edinburgh must take some credit for the greatest surgeon, Lister, who spent one-third of his active career in that University It was in Edinburgh that Lister began the investigations that led to his antiseptic theory

SOUTH-WEST ORTHOPAEDIC CLUB

The autumn meeting of the South-West Orthopaedic Club held at the Bath and Wessex Hospital Bath on September 10 1949 The chairman, Dr Kohn, was introduced by Miss Forrester Brown Clinical cases were shown and the problems of treatment of slipped upper femoral epiphysis were illustrated Miss Forrester-Brown emphasized that a successful functional result lasting ten years or more was often gained in severe unreduced cases by conservative treatment with simple extension and internal rotation exercises The treatment of talipes equino-varus was shown in all its stages Mr Bastow pointed out that in unilateral cases the opposite foot often showed a calcaneo-valgus deformity

Several successful cases of arthroplasty of the metacarpo-phalangeal joints of the hands were presented The heads of the metacarpal bones were excised as in the Mayo operation for hallux valgus Patients with ankylosing spondylitis and involvement of the hip joints were shown after excision of the head and neck of the femur on one side They were able to walk with the aid of a stick and without splintage Mr A Burton described a method of arthrodesis of the knee in rheumatoid arthritis Multiple drill holes were made across the joint which was then immobilised by an obliquely placed trifin nail Other cases included excision of the semilunar bone for Kienbock s disease the criterion for excision was that there were no osteoarthritic changes in pre-operative radiographs

REHABILITATION AND RESETTLEMENT OF THE DISABLED

British Council Course for Foreign Visitors—A course of instruction in Rehabilitation and Resettlement of the Disabled arranged by the British Council with the Ministry of Health and the Ministry of Labour was attended in October 1949 by twenty-five doctors from thirteen European countries In addition to a series of lectures on rehabilitation and allied subjects the course included visits to many industrial centres in London and the provinces, where the visitors were able to see at first hand the problems that have to be met and the methods used

FRANCE

FRENCH SOCIETY OF ORTHOPAEDIC SURGERY AND TRAUMATOLOGY

The twenty-fourth meeting of the French Society of Orthopaedic Surgery and Traumatology was held in Paris on October 7–8, 1949, under the presidency of Professor Guilleminet Among the subjects discussed were non-tuberculous affections of the sacro-iliac joints, cervico-brachial neuritis and the use of a bone bank The procedure adopted for discussions at the meeting was interesting in that the two principal speakers did not open the discussion but concluded it

During the week visits were arranged to many surgical clinics Much interest was shown in the use of an acrylic prosthesis for replacement of the diseased femoral head in chronic hip lesions At the Hospital for Sick Children a hip operation was shown to a large gathering with the aid of television Five fellows of the British Orthopaedic Association attended the meeting

VENEZUELA

VENEZUELAN SOCIETY OF ORTHOPAEDIC AND TRAUMATIC SURGERY

In Caracas Venezuela a new Society of Orthopaedic and Traumatic Surgery has been established under the chairmanship of Dr Andres Gutierres Solis The purpose of the Society is to advance the knowledge of orthopaedic surgery in Venezuela and to establish scientific relations with Great Britain and with all countries that have similar organisations The officers include Dr A Pietri Hijo (vice chairman) Dr Jorge Figarella (executive secretary) Dr Juan G Yanez (treasurer) and Drs Armando P[illegible] and Jose Antonion Villegas (assistant members) We welcome this development and look forward to [illegible] fruitful associations in future years

CORRESPONDENCE

GIANT-CELL TUMOR OF BONE

From DR LOUIS LICHTENSTEIN, M.D., LOS ANGELES, CALIFORNIA

To the Editor
Journal of Bone and Joint Surgery

DEAR SIR,

In the May 1949 issue of the Journal (British volume, 31-B, pp. 236-290) there appeared a series of articles dealing with the pathology, diagnosis, and treatment of giant-cell tumor of bone or osteoclastoma as the British prefer to call it. In one or another of these articles the validity of certain views expressed by Drs Jaffe, Portis and myself (1940) is questioned. It is important that the issues be clearly joined so that your readers may be enabled to arrive at some independent judgment, and I wonder therefore whether I may be accorded the privilege of clarifying some of the problems raised through the publication of this letter.

In so far as basic pathologic interpretation is concerned, we are in essential accord with Professor Willis. There appears to be substantial agreement that giant-cell tumor of bone represents a genuine neoplasm of non-osteoblastic connective tissue derivation, and that while many tumors are successfully treated by thorough curettement (or irradiation), some are undoubtedly aggressive and prone to recur and occasional ones behave like frank sarcomas either when initially observed or more often after one or more local recurrences. Willis holds further that histogenetically the connective tissue composing the tumor is committed to the formation of osteoclasts and with this the writer has no particular quarrel, although he is reluctant to subscribe to the idea that fully differentiated osteoclasts and osteoblasts are "readily interconvertible." In regard to giant-celled tumors, so called, of synovial or tenosynovial tissues, we agree entirely with Willis that such lesions are wholly unrelated to giant-cell tumor of bone and indeed go further in maintaining that they represent peculiar granulomas rather than true neoplasms. The condition has been described as such by Jaffe, Sutro and the writer (1941) under the head of pigmented villonodular synovitis, bursitis and tenosynovitis.

In the matter of specific details, however, there is significant difference of opinion. Thus it is the writer's impression that Willis is not as critical as he might be in accepting as genuine giant-cell tumors lesions that develop in young patients below the age of twenty years or that arise in the metaphysis rather than at the end of a long bone. In our experience, such lesions in the great majority of instances prove on close histologic scrutiny to be instances of other conditions, on the whole less serious than giant-cell tumor (non-osteogenic fibroma, benign chondroblastoma, bone cyst, etc.). In regard to the lesion of benign chondroblastoma of bone particularly (chondromatous osteoclastoma in Willis' terminology) there is a sharp divergence of opinion. This writer has observed material from fifteen or more relevant cases to date and is firmly convinced on the basis of evidence presented elsewhere (1942, and in the press) that the lesion in question represents a distinctive benign tumor of cartilage-forming connective tissue derivation and is unrelated histogenetically to giant-cell tumor.

Two of the papers in the same issue, by Prossor and Ellis respectively, purport to show the advantages of radiation therapy for giant-cell tumor. The first of these deals with a rather miscellaneous group of skeletal lesions including many in young patients, most of which were not identified by biopsy prior to irradiation. In lieu of histological proof it is stated that the "radiographs showed benign giant-cell tumor." There is more involved than semantics in pointing out that radiographs cannot possibly show a giant-cell tumor. They show a defect or a lesion in the affected bone interpreted as a giant-cell tumor, and Brailsford to the contrary notwithstanding, there are very definite inherent limitations in the matter of interpretation as Prossor himself freely admits. If one elects to irradiate a lesion presumed to be a giant-cell tumor without confirmation by at least punch biopsy, that is his privilege, but by the same token, there is little justification for presenting such observations as scientific evidence.

The validity of this objection is recognised in the paper by Ellis, but here again almost half the cases presented are in patients between the ages of ten and twenty years, and much of the sketchily reported pathologic data in support of the diagnosis appears to be of equivocal or dubious nature. It is unfortunately

Jaffe, Portis and Lichtenstein (1940) *Archives of Pathology*, **30**, 993
Jaffe, Sutro and Lichtenstein (1941) *Archives of Pathology*, **31**, 731
Lichtenstein (1942) *American Journal of Pathology*, **18**, 969
Lichtenstein (*in the press*) *Cancer*

true that many lesions are still labelled giant-cell tumor by pathologists with limited experience in bone pathology, simply because they contain a scattering of multinuclear cells. The inclusion of dubious cases also detracts from the value of the paper by Windeyer and Woodyatt and in the absence of convincing proof the writer would seriously question, for example, whether the cases illustrated in Figures 5 and 6 and 13 and 14 represent osteoclastomas as stated.

In the provocative paper by Professor Russell entitled 'Malignant Osteoclastomata', the view is expressed that the grading of giant-cell tumors on the basis of changes in their stromal cells as advocated by Jaffe, Portis and myself appears valueless. On reading further one finds that this categorical statement is based upon inferences gleaned from a single case which Russell chooses to interpret as a malignant giant-cell tumor but which the writer feels may conceivably represent an osteogenic sarcoma. This same paper also raises an interesting problem of interpretation in regard to the nature of certain sarcomas developing in association with Paget's Disease. It is perhaps not generally appreciated that Paget's sarcoma may be of varying histologic types. Specifically, many, though by no means all, are osteogenic sarcomas, some are fibrosarcomas, and occasional ones are quite anaplastic and replete with tumor giant cells. It is the latter tumors particularly that Russell regards as malignant osteoclastomas—a point of view that is rather debatable. Sarcomas of soft parts not infrequently come to contain numerous multinucleated tumor cells as an expression of rapid and unrestrained growth. When the same phenomenon is observed in relation to a sarcoma of bone, why should the latter necessarily be labelled as a malignant giant-cell tumor?

Finally, such unqualified statements as "osteoclastomata arise in the metaphyses of long bones" and "bone cysts represent healed osteoclastic lesions" (appearing in one or another of the articles cited) would hardly meet with general acceptance.

Very truly yours,

August 24, 1949 LOUIS LICHTENSTEIN

From PROFESSOR DOROTHY S. RUSSELL, M.D., SC.D., F.R.C.P., LONDON, ENGLAND

To the Editor
Journal of Bone and Joint Surgery

DEAR SIR,

Thank you for giving me the opportunity both of reading Dr Lichtenstein's letter before its publication and of answering those parts in which he refers to my article on 'Malignant Osteoclastoma'.

The pathologist who is confronted by a metastasis, as in my Case 2, which has the microscopical appearances of an ordinary benign osteoclastoma and is devoid of any unusual types of "stroma cells", must conclude that the latter are not essential to the clinical manifestations of malignancy. How then is it possible to subscribe to a system of grading which is based upon morphological alterations in the stroma cells? Dr Lichtenstein feels, alternatively, that the tumour in my Case 2 'may conceivably represent an osteogenic sarcoma'. His opinion is of course based upon my account and photomicrographs. I don't believe that any competent pathologist would make such a diagnosis on the section, or that Dr Lichtenstein will maintain this view when he is able to examine it for himself.

With regard to Paget's osteitis deformans, it is of course generally known—at any rate by British pathologists—that the sarcomas complicating this condition are of various histological types. Hence it is surely not surprising if the malignant osteoclastoma should occasionally appear. But if Dr Lichtenstein's scepticism has really reached the point, as it would appear from his letter, of considering me guilty of confusing the osteoclastic type of giant cell with the multinucleate giant cells of osteogenic sarcoma and of the anaplastic sarcomas of soft tissues, then I must regret his imputation of gross incompetence without the satisfaction of knowing precisely upon what this is based.

Yours truly,

October 17, 1949 DOROTHY S. RUSSELL

Book Reviews

SURFACE AND RADIOLOGICAL ANATOMY FOR STUDENTS AND GENERAL PRACTITIONERS By A B Appleton M A M D (Cantab) Professor of Anatomy, London University (St Thomas's Hospital Medical School) W J Hamilton, M D, D Sc F R C S I, Professor of Anatomy London University (Charing Cross Hospital Medical College), sometime Regius Professor of Anatomy Glasgow University and G Simon, M D, D M R E (Cantab) Demonstrator of Radiological Anatomy St Bartholomew's Hospital Medical College and Assistant Radiologist St Bartholomew's Hospital Third edition 10 × 8 in Pp viii + 332, with 390 figures Index and Appendix 1949 Cambridge W Heffer & Sons Ltd Price 35/-

This is the third edition of a book aiming to provide an introduction to the study of features which are accessible to examination in the living subject This statement is too modest for the book can be recommended also as a valuable reference work and companion for the post graduate student and trainee specialist It provides an atlas of normal surface and radiological anatomy and in addition illustrates deeper structures mainly in relation to surface contours In the last connection the book tends to deviate a little from its avowed purpose by occasionally developing details of descriptive anatomy which are inappropriate This however, is a small point by comparison with the excellent radiological studies and the relation of these to the living subject For further editions we would suggest the fuller use of illustrations depicting such common endoscopic examinations as those of the bladder rectum and vagina It is strange that these are missing when gastroscopy, an examination few men are likely to perform is so beautifully illustrated By comparison the traditional sagittal sections of the cadaveric pelvis or head are rather out of place As it is in the field of radiology that we think this book is so good we venture to make our only serious criticism namely that it should be unnecessary to place arrows on so many of the obvious details presented by the radiographs Students should be made to find out things for themselves from the descriptions given radiologists should not be encouraged to commit the unforgivable sin of disfiguring their handiwork —Norman Capener

THE SCIENCE AND ART OF JOINT MANIPULATION—Vol I—THE EXTREMITIES By James Mennell M A M D Consulting Physician in Physical Medicine St Thomas's Hospital and former Lecturer to the Physiotherapy Training School Hon Fellow Chartered Society of Physiotherapy Second edition 10 × 8 in Pp xv+215 with 299 figures Index 1949 London J & A Churchill Ltd Price 24/-

James Mennell

During all his professional career James Mennell has made a particular study of manipulation For many years he was almost alone in his endeavours to show that this branch of Physical Medicine was an essential part of therapy He knew the methods of the unorthodox some of which led to cure and others to disaster Some thirty years ago he had to face the fact that the public looked primarily to the osteopath for manipulative treatment and the medical profession tended to scoff at it At that time he was studying its rationale which was hardly considered by the manipulator Gradually he has shown the great detail of his study of anatomy and physiology relating to manipulation and proved that the function of the limbs is a problem worthy of thought His writings based on a wide experience have attracted the attention of English-speaking nations He has spent many years in teaching the study of manipulation A second edition of The Science and Art of Joint Manipulation ' is most welcome at this time when departments of physical medicine are developing all over the country This volume concerns the extremities and we are promised a second volume on the spine in a matter of months

The first chapters deal with basic considerations and useful rules for manipulation, without any attempt to enumerate the indications The technique of manipulation of all limb joints is then described in meticulous detail, and warning is given of the dangers The chapters on the finger joint and the knee are of outstanding value The author stresses function and movement, especially in the smaller joints of which he has made a detailed study He writes of treatment after manipulation Almost avoiding terms such as rehabilitation and occupational therapy, he tells us the value of using the garden shears and a typewriter Manipulation for dislocation or fracture is outside the scope of the book The many figures mostly f

photographs are well chosen especially those of manipulation of the knee The art of manipulation is more easily learned by watching an expert than by looking at still photographs of him at work and in consequence Mennell is preparing sound films

The production of this book is excellent the arrangement is helpful and the index is sufficient The practising orthopaedic surgery or physical medicine should read Mennell s work and realise the importance of the detail that he has been able to enunciate after many years of study —St J D BUXTON

A COMPANION IN SURGICAL STUDIES By Ian AIRD Ch M F R C S, Professor of Surgery in the University of London Director of the Surgical Unit Postgraduate Medical School of London 10 8 in Pp viii—1060 Index 1949 Edinburgh E & S Livingstone Ltd Price 63/-

Can a book of 1000 pages on surgery without a single illustration be anything but dull? Aird s book proves the contrary It is easy to read and on opening the book at random one is inclined as with all good literature to continue browsing The book fulfils admirably the author s intention of giving a post-graduate a contemporary view of general surgery and all surgical specialties other than his own It is not written for the undergraduate nor is it a treatise on operative surgery Its chief merit lies in the author s knowledge of current surgical literature there are many thousands of references to papers published in the past ten years If it has a fault it lies in its lack of discrimination between the important and the unimportant for example twenty-five varieties of tumours of the kidney are listed Unfortunately for the orthopaedic surgeon the book does not cover the whole of surgery, the author has intentionally omitted all reference to orthopaedics —George PERKINS

PATHOLOGY OF THE NERVOUS SYSTEM By J Henry BIGGART, C B E M D, D Sc Professor of Pathology Queen s University, Belfast, Pathologist to the Royal Victoria Hospital Belfast Hospital for Sick Children Claremont Street Hospital for Nervous Diseases, Mater Infirmorum Hospital Foreword by Professor A Murray Drennan M D, F R C P E F R S E Second edition 9×6 in Pp xii+352 with 232 figures and 10 coloured plates Index 1949 Edinburgh E & S Livingstone Ltd Price 21/-

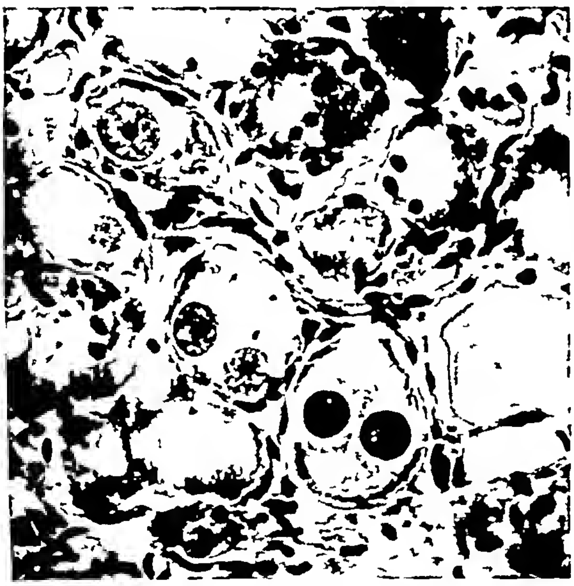


FIG 222
Ganglioneuroma of the right adrenal in a child of eight years Section is taken from one of the cellular areas Note the mature cells and their capsules Many are binucleated Nissl substance is confined to the periphery of the cytoplasm H and E ×320

It is a pleasure to welcome the second edition of this useful introduction to the pathology of the nervous system It contains a considerable amount of new matter throughout and many fresh illustrations including the ten coloured plates The latter are excellent although Plates V and X show nothing that would not have been equally clear in monochrome Indeed the illustrations throughout are excellent and well amplify the text The author has managed to cover the subject remarkably completely and there are very few abnormalities of the nerve cell or system diseases which do not receive at least passing mention It is a necessary fault in a text-book of this size that fuller descriptions of many of the rarer conditions have to be omitted or reduced to a minimum Sometimes the author appears to hurry from one matter to the next with almost breathless haste The subject is large and expanding rapidly so that what was a reasonable size for a text book at the date of the first edition now thirteen years later appears to cramp the subject Or it may be that many conditions which were omitted from the first edition have been referred to in the second

The best sections of the book appear to the reviewer to be Chapters X to XII dealing with infections including encephalitis and Chapters XI and XIII on tumours of the nervous system Both these are copiously and well illustrated The chapter on encephalitis has been largely brought up to date although the most recent work on insect vectors in Japanese B encephalitis and the tick-borne Russian encephalomyelitis are not mentioned The chapter on tumours include descriptions of all the more common forms and the author s special interest in the pituitary gland is reflected in the excellence of the description of pituitary tumours The least satisfactory chapter is that on injury In this the important work of Denny-Brown and Russell on " acceleration concussion is referred to so briefly that its nature and the conclusions to be drawn . . .

it remain obscure the bibliography omits their paper No mention is made of the more recent experimental work and observations of American writers on neuronal damage in concussion of the brain or spinal cord This work has so changed our conception of concussion from that of ten years ago that the omission is regrettable Nor has the work on injuries of the peripheral nerves carried out during the war years found any reflection in the chapter on that subject An impression is conveyed here no doubt unintentionally that any swelling at the junction of a severed peripheral nerve indicate an unsatisfactory union

Taken as a whole this is a book which should admirably serve its purpose of stimulating the student by revealing the richness of the field of neuropathology, and showing how closely this subject is related to the pathology of other bodily systems —J G GREENFIELD

AN ACCOUNT OF THE SCHOOLS OF SURGERY, ROYAL COLLEGE OF SURGEONS DUBLIN 1789–1948 By J D H WIDDESS, M A (Dublin) L R C P & S I Librarian and Lecturer in Biology R C S I Foreword by William Doolin F R C S I, Hon Librarian Royal College of Surgeons in Ireland Editor of the Irish Journal of Medical Science 9¾ × 6¼ in Pp x + 107 with 16 plates Bibliography Appendix and Index 1949 Edinburgh E & S Livingstone Ltd Price 17/6

Although the date 1789 appears in the title of this book its opening pages cover the history of Irish surgery for many earlier centuries but such an introduction is necessary if the reader is to understand how the need for the new institution arose The steps taken by the founders of the College arouse admiration for their vision courage and faith which overcame almost insuperable difficulties The author, who is librarian and lecturer in biology in the College, illuminates with his knowledge every aspect of its early days and its later developments, he uses admirably brief and direct statement to convey the most comprehensive information in the least possible space the work will prove invaluable for reference not only on matters directly concerning the College but on many related subjects of these the story of the resurrectionists is given in graphic detail There are many vivid biographical sketches of the staff of the College and its distinguished sons, where the use of concise quotation renders the figures three dimensional These quotations are very numerous so that limitations of space may account for the absence of references Dr Widdess includes not only the personalities who brought to the school its early success and established its later reputation but also describes its buildings, furnishings locality syllabus fees examinations and resolutions its prizes its documents and its books The excellent plates illustrate some of the records and show many portraits of men whose names are now perpetuated in anatomical structures or clinical signs In consequence of the author s familiarity with early medical journals their views of the school are extensively quoted so that its early years are seen through the eyes of contemporaries

The policy of the College was remarkably enlightened from its very start, it anticipated many current views on medical teaching and long ago introduced methods which remain hoped-for reforms elsewhere In its first twenty years the College revolutionised surgical teaching in Dublin Outstanding among its achievements was Colles s work in relating anatomy to surgery, while Macartney was the first teacher in Great Britain and Ireland to break away from the renaissance tradition and to teach anatomy on topographical instead of systemic lines As early as 1841 the College established a chair of preventive medicine and the course of study came gradually to embrace all subjects required for general practice but it is notable that at its very inception space was found for instruction in the history of medicine The expansions which took place in 1805–10 and again in 1825 with government support were but preludes to a programme which was soon to make the College a great national institution and culminated in its absorption of two private schools in 1889 an incident commemorated in its title Schools " Had the founders taken as its motto *Tandem fit surculus arbor*, the College would have nobly justified their choice

There are few misprints and the book fully maintains the high standard of its producers There is a good index and there are some useful appendices, but the brief bibliography appears to do little justice to the author s reading —John KEEVIL

ERNIA DEL DISCO E SCIATICA VERTEBRALE By Francesco DELITALA Ordinario di Clinica Ortopedica Direttore dell'Instituto Rizzoli di Bologna, and Augusto BONOLA Primo Aiuto dell'Instituto Rizzoli, Inc di Clinica Ortopedica dell'Univer di Modena 9½ × 6¾ in Pp 213, with 108 figures Bibliography 1949 Bologna Licinio Capelli Price Lire 1800

This is a comprehensive presentation of hernia of the intervertebral disc and its relation to sciatica The subject is covered systematically in great detail and with great care Particular attention is paid to the histo-pathology of the condition and the clinical aspects and details of operative treatment are adequately discussed The illustrations are delightful, and even those who were ignorant of the language could almost read the book by looking at the pictures The bibliography covers the whole of the literature on intervertebral lesions and it is probably the most valuable part of the book —Bryan McFARLAND

BOOKS RECEIVED

These books are acknowledged with grateful thanks Selections will be made for review as space permits and in the interest of our readers

MAJOR ENDOCRINE DISORDERS By S Leonard SIMPSON M A M D F R C P 1948 London Oxford University Press

CAMPBELL S OPERATIVE ORTHOPEDICS Editor J S SPEED M D Associate Editor Hugh SMITH M D Second edition 1949 London Henry Kimpton

ILLUSTRATIONS OF SURGICAL TREATMENT Instruments and Appliances By Eric L FARQUHARSON M D F R C S (Ed) F R C S (Eng) Foreword by the late Sir John FRASER Bt K C V O M C , M D Ch M F R C S (Ed) 1949 Edinburgh E & S Livingstone Ltd

L ORGANISATION DES OS By P LACROIX 1949 Paris Masson et Cie

ON THE CONTRIBUTIONS OF HUGH OWEN THOMAS SIR ROBERT JONES, JOHN RIDLON, M D TO MODERN ORTHOPEDIC SURGERY By H Winnett ORR M D With a Supplement on RIDLON AND HIS SHARE IN MOULDING ORTHOPEDIC SURGERY by Arthur STEINDLER M D 1949 Illinois U S A Charles C Thomas Oxford Blackwell Scientific Publications Ltd

TUMOURS OF BONE By Charles F GESCHICKTER M D and Murray M COPELAND M D Third edition 1949 Philadelphia London Montreal J B Lippincott Company

ARMY FOOT SURVEY An Investigation of Foot Ailments in Canadian Soldiers By Colonel R I HARRIS M C R C A M C and Major T BEATH, R C A M C 1947 Ottawa National Research Council of Canada

FRACTURES AND DISLOCATIONS IN GENERAL PRACTICE By John HOSFORD, M S F R C S Second edition revised by W D COLTART, M B , F R C S 1949 London H K Lewis & Co Ltd

THE MEDICAL ANNUAL 1949 Bristol John Wright & Sons, Ltd

X-RAY DIAGNOSIS FOR CLINICAL STUDENTS AND PRACTITIONERS By G SIMON M D B Ch (Cantab), F F R 1949 Cambridge W Heffer & Sons, Ltd

ANKYLOSING SPONDYLITIS Part I by F HERNAMAN-JOHNSON M D F F R D M R F Part II by W Alexander LAW O B E , M D , F R C S 1949 London Butterworth & Co (Publishers) Ltd

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